Technical Paper No. 307

Earthquake Reconstruction on Quetta (Railway) Division 1936—40

By

R. O. C. THOMSON, M.C., Assoc.M.Inst.C.E.,
Executive Engineer, Reconstruction
North Western Railway

CALCUTTA
PRINTED FOR THE RAILWAY BOARD
AT THE EAST INDIAN RAILWAY PRESS
1940

Copies obtainable from—
THE MANAGER OF PUBLICATIONS
DELHI

Price Re. 1-8-0 or 1s. 3d.

Forwarded with the compliments of the Secretary to the Railway Board of India.

New Delhi,

20th December 1940.

Technical Paper No. 307

Earthquake Reconstruction on Quetta (Railway) Division 1936—40

By

R. O. C. THOMSON, M.C., Assoc.M.Inst.C.E.,
Executive Engineer, Reconstruction
North Western Railway

CALCUTTA
PRINTED FOR THE RAILWAY BOARD
AT THE EAST INDIAN RAILWAY PRESS
1940

Copies obtainable from—
THE MANAGER OF PUBLICATIONS
DELHI

List of Agents in India from whom Government of India Publications are available.

(a) PROVINCIAL GOVERNMENT BOOK DEPOTS.

MADRAS.—Superintendent, Government Press, Mount Road, Madras.
BOMBAY.—Superintendent, Government Printing and Stationery, Queen's Road, Bombay.
SIND.—Manager, Sind Government Book Depot and Record Office, Karachi (Sadar).
UNITED PROVINCES.—Superintendent, Printing and Stationery, U. P., Allahabad.
PUNJAB.—Superintendent, Government Printing, Punjab, Lahore.
CENTRAL PROVINCES.—Superintendent, Government Printing, Central Provinces, Nagpur.
ASSAM.—Superintendent, Assam Secretariat Press, Shillong.
BIHAR.—Superintendent, Government Printing, P. O. Gulzarbagh, Patna.*
NORTH-WEST FRONTIER PROVINCE.—Manager, Government Printing and Stationery, Peshawar.
ORISSA.—Press Officer, Secretariat, Cuttack.

(b) PRIVATE BOOKSELLERS.

Advani & Co., The Mall, Cawnpore.
Aero Stores, Karachi.*
Agarwala & Co., Messrs. J. N. P., Padri-ki-Haveli, Patna City.
Army Musketry Stores, Moga.
Associated News Agency, Big Bazar, Quilon.
Banthiya & Co., Ltd., Station Road, Ajmer.
Bengal Flying Club, Dum-Dum Cant. *
Bhatia Book Depot, Saddar Bazar, Ranikhet.
Bhawani & Sons, New Delhi.
Bombay Book Depot, Charni Road, Girgaon, Bombay.
Book Company, Calcutta.
Booklover's Resort, Taikad, Trivandrum, South India.
British Stationery Mart, Peshawar.
Buckingham & Co., Booksellers and Stationers, Greenwood Street, Sialkot City.
Burma Book Club, Ltd., Rangoon.
Butterworth & Co. (India), Ltd., Calcutta.
Cambridge Book Co., Booksellers, New Dak Bungalow Road, Patna.
Careers, Mohini Road, Lahore.
Chandrakant Chimanlal Vora, Ahmedabad.
Chatterjee & Co., 3 Bacharam Chatterjee Lane, Calcutta.
Chukervertty, Chatterjee & Co., Ltd., 13 College Square, Calcutta.
Company Law Institute, Thyagarayanagar and Chiney & Sons, Bookseller, &c., Dhantoli, Nagpur.
City Book Club, 98 Phayre Street, Rangoon.
C. P. Circulating Library and Book Depot, Civil East St., Cantonment, Jubbulpore.
Das Gupta & Co., 54/3 College Street, Calcutta.
Dastane Brothers, Home Service, 456 Raviwar Peth, Poona 2.
Delhi and U. P. Flying Club, Ltd., Delhi. *
Eastern Publishing and Stationery, Ltd., 10 Chamberlain Road, Lahore.
Educational Book Depot, Mahal Road, Nagpur.
English Book Depot, Ferozepore.
English Book Depot, Taj Road, Agra.
English Bookstall, Karachi.
English Book Store, Abbottabad, N.-W. F. P.
Faqir Chand Marwah, Peshawar Cant.
Gautama Brothers & Co., Ltd., Meston Road, Cawnpore.
Goyal & Goyal, Publishers and Booksellers, Jaipur City.
Higginbothams, Madras.
Hindu Library, 137/F, Balaram De Street, Calcutta.
H. L. College of Commerce, Co-operative Stores, Ltd., Ahmedabad.
House of Knowledge, Booksellers and Publishers, Palliagraharam P. O., Tanjore.
Hyderabad Book Depot, Chaderghat, Hyderabad (Deccan).
Ideal Book Depot, Rajpur Road, Dehra Dun.
Ideal Book Depot, Big Bazar, Meerut.
Idandas Book Co., Connaught Circus (opposite Scindia House), New Delhi.
Imperial Book Depot, and Press, near Jama Musjid (Machhliwalan), Delhi.
Imperial Publishing Coy., Lahore.
Indian Army Book Depot, Dayalbagh, Agra.
Indian Army Book Depot, Daryaganj, Delhi.
Indian Book Shop, Benares City.
Indian School Supply Depot, Central Avenue South, P. O. Dharamtala, Calcutta.
Insurance Publicity Co., Ltd., Lahore.
International Book Service, Poona 4.
International Bookstall, Market, Kolhapur.
Jaina & Bros., Mori Gate, Delhi, and Connaught Place, New Delhi, Messrs. J. M.
Jain & Bros., Messrs. M. B., Sarafa Road, Gwalior.
Joshi, Mr. V. G., Devgad Baria (Piplod), Bombay.
Kamala Book Depot, 15 College Square, Calcutta.
Keale & Co., 65 Britto Road, Karachi Sadar.
Keshao Bookstall, Khadibazar, Belgaum.
Kitabistan, 17-A, City Road, Allahabad.
Krishnaswami & Co., Teppakulam, P. O. Trichinopoly Fort, Messrs. S.
Lahiri & Co., Ltd., Calcutta, Messrs. S. K.
Little Flower & Co., 44 Linga Chetty St., G. T., Madras.
Local Self-Govt. Institute, Bombay.
London Book Co. (India), Arbab Road, Peshawar, Murree, Nowshera, and Rawalpindi.
Lucknow Publishing House, Lucknow.
Lyall Book Depot, Lyallpore and Agents for Income-tax, Law and Allied Publications only.
Macmillan & Co., Ltd., 294 Bow Bazar Street, Calcutta.
Mackwin & Co., Booksellers, Stationers and News Agents, Inverarity Road, off Elphinstone Street, Karachi Sadar.
Malhotra & Co., Post Box No. 94, Lahore, Messrs. U. P.
Malik & Sons, Sialkot City.
Mathur & Co., Messrs. B. S., Chatur-Vilas, Paota, Civil Lines, Jodhpur (Rajputana).
Minerva Book Shop, Anarkali Street, Lahore.
Modern Book Depot, Bazar Road, Sialkot Cant.
Modern Times, Moheni Road, Lahore.
Mohanlal Dossabhai Shah, Rajkot.
Mohendra Brothers, Lashkar, Gwalior State, Messrs.
Nandkishore & Bros., Chowk, Benares City.
National Book House, Jeonamandi, Agra.
New Book Co., "Kitab Mahal", 192 Hornby Road, Bombay.
Newman & Co., Ltd., Calcutta, Messrs. W.
Oxford Book and Stationery Company, Delhi, Lahore, Simla, Meerut and Calcutta.
Parikh & Co., Baroda, Messrs. B.
Pioneer Book Supply Co., 20 Shib Narayan Das Lane, Calcutta and 219 Cloth Market, Delhi.
Parakash Educational Stores, Near Tehsil, Meerut.
Popular Book Depot, Grant Road, Bombay.
Punjab Sanskrit Book Depot, Lahore.
Punjab Religious Book Society, Lahore.
Rainas News Agency, The Bund, Srinagar, Kashmir.
Raghunath Prasad & Sons, Patna City.
Rajaji Press, Ltd., Derakottah.
Rama Krishna & Sons, Booksellers, Anarkali, Lahore.
Ram Krishna Bros., Opposite Bishrambag, Poona City.
Ram Narain Lal, Katra, Allahabad.
Ramesh Book Depot and Stationery Mart, Kashmeri Gate, Delhi.
Ray & Sons, 43 K. & L. Edwardes Road, Rawalpindi, Murree and Peshawar, Messrs. J.
Roy Chowdhury & Co., 72 Harrison Road, Calcutta, Messrs. N. M.
Saraswati Book Depot, 15 Lady Hardinge Road, New Delhi.
Sarcar & Sons, 15 College Square, Calcutta, Messrs. M. C.
Sarkar & Sons, Ltd., 1-1-1C, College Square and 6 Hastings Street, Calcutta, Messrs. S. C.
Sharada Mandir Ltd., Nai Sarak, Delhi.
Shri Samarth Book Depot, Girgaon, Bombay.
Standard Bookstall, Karachi.
Standard Bookstall, Quetta.
Standard Book Depot, Lahore, Dalhousie and Delhi.
Standard Law Book Society, 69 Harrison Road, Calcutta.
Subhan, Mr. M. A., Bilaspur.
Tara & Sons, Razmak (India), Messrs. B. S.
Taraporevala Sons & Co., Bombay, Messrs. D. B.
Thacker & Co., Ltd., Bombay.
Thacker, Spink & Co., Ltd., Calcutta and Simla.
Times Book Depot, Mohan Lal Road, Lahore.
Tripathi & Co., Booksellers, Princes Street, Kalbadevi Road, Bombay, Messrs. N. M.
Uberoy, J. C., Journalist, Printer and Publisher, Jaycu House, Alexandra Road, Ambala.
Universal Book Depot, 58 Hazratganj, Lucknow.
University Book Agency, Kacheri Road, Lahore.
Upper India Publishing House, Ltd., Literature Palace, Amin-ud-daula Park, Lucknow.
Varadachary & Co., Madras, Messrs. P.
Venkatasubban, A., Law Bookseller, Vellore.
Venkataraman, Mr. B., Nagapatam.
Verma's Cambridge Book Depot, Patna.
Wheeler & Co., Allahabad, Calcutta and Bombay, Messrs. A. H.
Young Man & Co. (Regd.), Egerton Road, Delhi.

* Agent for publications on Aviation only.

This Technical Paper, which issues from the office of the Railway Board, India, is not an official publication. Neither the Government of India nor the Railway Board are responsible for statements made or opinions expressed in the paper.

L. H. SWAIN,

Director, Civil Engineering,

Railway Board

New Delhi,

20th December 1940.

CONTENTS

Page

Introduction 7

Chapters—

I. Inception, Scope and Cost of the project 11

II. The danger area. Strengthening and Safe Exit 14

III. Seismic Factor and Development of Designs.. 17

IV. Unframed Buildings of "Banded" type 22

V. Structural Framed Buildings. 25

VI. Proportioning Concrete, and Economies in Cement 30

VII. Semi-permanent types 41

VIII. Modern Sanitary Installation 45

IX. Minor engineering points of interest, economies, plinth areas and costs (including final) 50

Appendices—

I. Design of Earthquake Proof Buildings. General Principles and Rules 54

II. Design Data adopted by G. C. Trehan for Earthquake Resisting Buildings on Quetta Division with subsequent modifications .. 57

III. Instructions for Beam Test for Concrete 60

IV. Specification for Aggregates 61

V. Instructions for Design of Concrete Mixtures 63

Plates—

1. Illustrating Quetta Railway Building Reconstruction Program and Epicentres of severe earthquakes since 1852 65
2. Illustrating standards of Earthquake Protection to Buildings obtaining on Quetta Division on Completion of the 1936-40 Reconstruction Project 66
3. Light Banded Type. Yaru Station Building 67
4. Quarters in Cool Areas for Menials and Gangmen 68
5. Light Banded Type of Quarters at Sibi 69
6. Semi-Permanent Junior Subordinates Quarters in Cool Areas. .. 70
7. Diagram showing Crumple Sections 71
8. Semi-Permanent Menials Quarters with Raised Plinth for use in Hot Areas 72
9. Assistant Divisional Officers' Bungalows at Quetta 73
10. Doors for Staff Quarters; Quetta Reconstruction 74
11. Line Diagrams showing Areas of Typical Quarters 75
12. Beam Testing Sheet 76
13. Special Details, i.e. Hollow Brick Roof Covering at Sibi, Pin Hinged Swivel Doors, Post and Rafter connexion for Rail Framed Verandahs, Kitchen Fire Places, Superior Fire Places, Frameless Courtyard Wall Door with Strap Hinges to Open Flat against Wall .. 77
14. Septic Tank for Running Rooms at Sibi 78

INTRODUCTION

1. At 3-03 a.m. in the darkness of the early morning of 31st May 1935, occurred the disastrous earthquake in which there perished in Quetta about twenty thousand persons. At neighbouring villages and in Kalat State the loss of life amounted to about seven thousand. The number of injured probably exceeded these figures. The dotted line marked 15 on Plate No. 1 shows approximately the 68 miles long and 16 wide epicentre of the 1935 earthquake.

2. As is usual in earthquakes the shock was most severe where there existed pockets of water-bearing alluvial soil. At Quetta Staff College, which is on a hard dry shingle and clay plain, the shock, though severe, was not destructive. In the Railway Area, where the sub-soil water table is only about 5 feet to 15 feet below the surface, the shock was at its greatest. Practically all railway buildings which were not of earthquake resisting design or of "pucca" type of construction were destroyed. Particularly tragic was the fate of neighbouring small colonies (such as at Sheikhmandah) of European subordinate communities, the life's savings of whose members were lost.

3. As part of the Railway reconstruction program there has been installed in the entrance to the new Quetta Station Building a tablet to the 154 railwaymen and 489 relatives of railwaymen who were killed in the 1935 earthquake. In addition, one of the three sculptured stone gables of the old station building was dismantled after the stones had been numbered, and has been re-erected on a reinforced concrete frame (with an appropriate tablet) as the entrance porch to the new Divisional Office.

4. From the following pages will be learned the extent to which railway buildings to earthquake resisting standards have been provided in Baluchistan, what measures have been taken to provide by strengthening and easy exit for the safety of occupants of standing old buildings, technical details associated with the execution of a project of this kind, and some recommendations.

5. Throughout the planning and the execution of the project (a period exceeding four years) the trend of cost has been downward. In place of elaborate details involving payment at high rates simple and cheaper substitutes have been devised, modifications have been made in standard types so as to remove points of weakness, modern methods of concrete control have given strength with economy, revisions in contract documents (the consequence of bitter controversies and hard experience) have been introduced as protection against claims. Recommendations relating to such subjects as these have been made to the proper authorities, but in order to render this paper as complete as possible notes on some of them have been included.

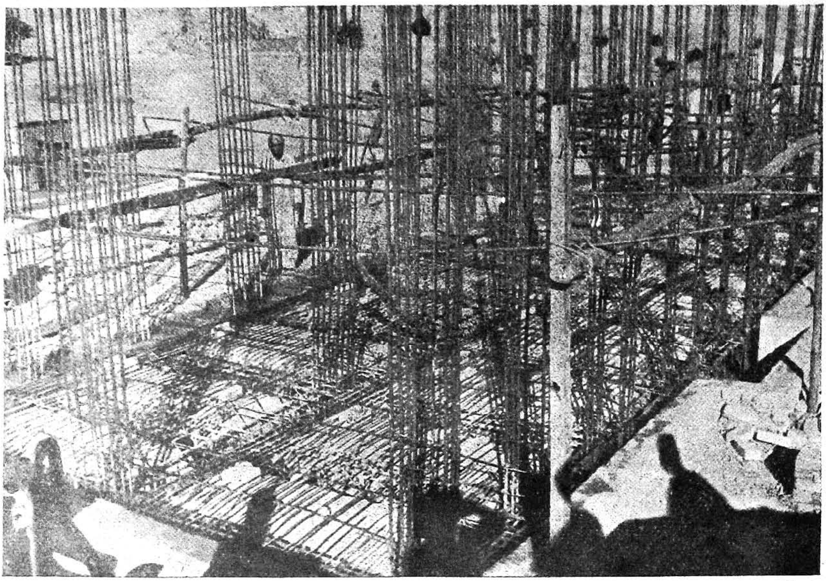
6. The Quetta earthquake of 1935 is not likely to be the last which will occur in India. From material available in this and other papers and in the designs offices at Lahore and elsewhere it should be possible to produce standard designs of anti-seismic buildings at a cost very slightly exceeding that of ordinary types, and of equal comfort. Thus can be avoided the delay and expense of undertaking from first principles to approved designs on the occurrence of every earthquake entirely fresh sets of designs. Furthermore it will become possible by executing future new construction in seismic areas in accordance with anti-seismic types, to guard against repetitions of destruction such as occurred in the Bihar and Quetta earthquakes. Thus, at a trifling premium, may be insured the lives and property of future generations.

R. O. C. THOMSON,

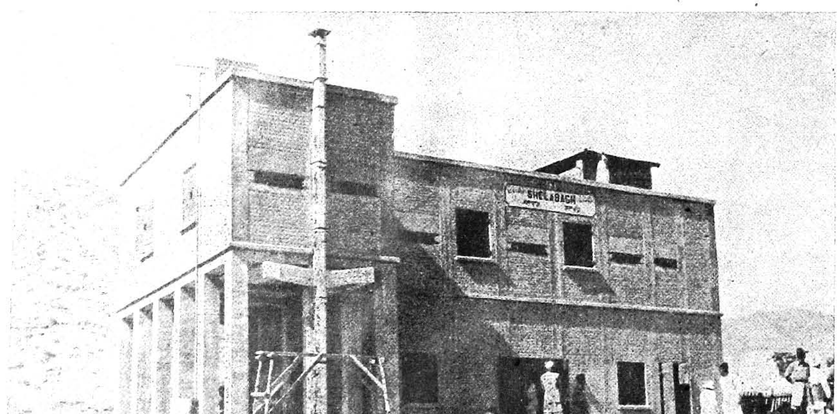
Executive Engineer,

Reconstruction, N. W. Railway,

Quetta.



R. C. C. Raft foundation and column reinforcement for Shelabagh combined station building and defence post.



Two-storey station building and defence post at Shelabagh (Flush system sanitation is provided for the garrison).

Technical Paper No. 307

EARTHQUAKE RECONSTRUCTION ON QUETTA (RAILWAY) DIVISION, 1936-40

By

R. O. C. THOMSON, Executive Engineer, Reconstruction,

North Western Railway.

CHAPTER I

Inception, Scope and Cost of the Project.

1. The decision of the Government of India to rebuild Quetta on its existing site is contained in Foreign and Political Department Resolution No. D.557-Eq./35, dated New Delhi, the 24th December 1935. In the same Circular are contained orders for the formation of co-ordinating Committees, namely a Central Committee at the Headquarters of the Government of India, and a Local Committee at Quetta.

2. On the general subject of the earthquake area of Baluchistan paragraphs 7 and 8(1) and (2) of the Resolution read as follows—

"7. The view of the Director of the Geological Survey of India, reinforced by that of experienced engineers, is that earthquake-proof construction will be a necessary precaution anywhere in Baluchistan; and that, if this precaution is adopted, reconstruction in Quetta itself is likely to be just as safe as, if not safer than, building anywhere else in Baluchistan. The whole of Baluchistan must be regarded as an earthquake area in which further shocks may be expected to occur from time to time, but earthquake shocks in Baluchistan are not due to volcanic activity and therefore they are unlikely to recur in the same regions. They are the result of a condition of special strain in the rock formation of the area; the sudden movement of the rocks under enormous pressure causes the earthquake; but the movement itself relieves the stresses to which they have been subjected in the past and therefore reduces the likelihood of future earthquakes in the same place. Past experience shows that the focus of earthquake activity in Baluchistan has gradually been moving in a north-westerly direction and the probability therefore is that, if further serious shocks do occur, their epicentres will not be on the same line as the earthquake of 31st May 1935.

The numerous tremors and after-shocks that have occurred in Quetta since May 31st are the normal accompaniment of every severe earthquake; and so far from their being regarded as the precursors of another severe shock, there is good reason to believe that Quetta is a safer area to build on than any area to the north or north-west.

8(1) The intensity of the earthquake in Quetta over a limited area was extremely high—higher than that of the Bihar earthquake* and yet such earthquake-proof buildings as there were in that area withstood the shock, while even ordinary buildings solidly constructed with good mortar were not seriously damaged. It was the extremely poor quality of the building in Quetta City that contributed more than anything else to the magnitude of the disaster.

(2) There is no place in Baluchistan within a radius of 150 miles from Mastung where it would be legitimate to build in future without taking special precautions against earthquakes, and the standard of these precautions would probably have to be the same everywhere in this area."

3. The Technical Sub-Committee of the Central Quetta Reconstruction Committee set to work to draw up a comprehensive statement of general principles and rules for the design of earthquake-proof buildings. The seismic factor decided upon following the 1935 earthquake for the design of future buildings was G/8, namely 12½ per cent of gravity. These general principles and rules if applied in full, combined with as high a seismic factor as G/8 (the factor of G/10 had been adopted for Railway works following the 1931 earthquake) result in so high a factor of safety and such excessive cost that they were modified later. The subject is more fully dealt with in the chapter on designs.

4. The amounts of the various estimates for railway reconstruction reflect the variations in the reconstruction policy. The first estimate (1935) amounting to fifty-four lakhs covered only reconstruction in the collapsed zone. The next (abstract) estimate (one hundred and five lakhs), in accordance with which railway reconstruction work was started early in 1936, was superseded before it had been formally sanctioned, by a much more comprehensive estimate which took account of recommendations of the Central Reconstruction Committee to date, including demolition and reconstruction to earthquake standards of all residential accommodation in the "blue" (danger) area whether damaged or not (see area enclosed by pink border in Plate No. 1). For safety of train working instruments stations on main lines were included in this category. (See minutes of Technical

* Subsequent investigations indicate that the Bihar quake was the more severe.

Sub-Committee, dated 4th August 1936). This estimate which amounted to 143 lakhs, covered not only replacement in the collapsed and shaken areas, but also the demolition of and the rebuilding to earthquake resisting standards of all railway standing katcha type living quarters*throughout the earthquake area of Baluchistan (see Plate No. 1) as well as all station buildings on main lines (whether damaged or not) in the danger area, in order to give security to essential train working instruments.

5. Before this estimate was sanctioned the policy underwent a further change, the nature of which may be summarized as reconstruction in the collapsed and shaken areas only, in which were included for strategic and geological reasons, Shelabagh and Chaman (not the whole Baluchistan earthquake area) and relaxation of the rules relating to the use of framed structures. A revised statement of costs amounting to Rs. 87½ lakhs (since supported by the sanctioned abstract estimate amounting to Rs. 87,23,300) which was prepared to conform to the latest policy of retrenchment, provided for reconstruction in only the collapsed and shaken zones, see Plate No. 2, (in which Sibi is included) plus Shelabagh and Chaman. Elsewhere in the danger area safe exit arrangements only were to be provided.

6. Conforming to this policy and making use of every justifiable source of economy (for details of which see Chapter 9) the final figure of the project is a saving of about 11 lakhs on the sanctioned estimate, leaving the probable completion figure as about Rs. 76,00,000.

Apart from expenditure on works such as provision of a modern sewage and sanitary installation, land acquisition, roads and fences, strengthening and safe exit arrangements outside the collapsed and shaken areas, the project has comprised the building to earthquake resisting standards of 2639 units of quarters (including 1259 in Quetta) and 106 service buildings (66 in Quetta). These figures are additional to the 569 units of quarters (59 in Quetta) and 18 service buildings (4 in Quetta) which had been built as a result of the Mach earthquake in 1931 to earthquake resisting design prior to the 1935 earthquake.

It is noteworthy that not only was the N. W. Railway far ahead of other departments in Baluchistan in anti-seismic construction before the 1935 disaster, but it has since then undertaken at moderate cost a most comprehensive program of earthquake protection, and has been the first to complete it.

---

* See minutes of the Technical Sub-Committee, dated 18th January 1937, and of the Central Committee, dated 8th April 1937 and 8th June 1937.

CHAPTER II

The Danger Area—Strengthening and Safe Exit.

7. One of the most difficult problems to be solved in formulating the policy and framing an estimate for the cost of earthquake reconstruction on Quetta Railway Division was the extent of the danger area and the degree of security to be provided in areas outside that affected by the earthquake of 31st May 1935. The distortion of the Baluchistan mountain region caused by the gradual convergence of two deep-seated and stable masses situated in Central Asia and Peninsular India respectively, with consequent excessive folding and occasional violent rupture giving rise to earthquake shocks, is a well known and widely accepted theory. It is thus apparent that frequent and severe earthquakes are to be expected in Baluchistan.

8. Arising from the 1935 disaster, investigations were made to ascertain the earthquake danger area, and it was noticed by the Geological and Survey Departments, that by placing over a map on which were marked the epicentres of all important Baluchistan earthquakes since 1852, a map overlay on which was shown the area of "negative gravity," a very close agreement between the two areas was found. The danger area so defined is that enclosed within the shaded border on Plate No. 1. It will at once be noticed how large a proportion (actually about 542 miles) of Quetta Railway Division lies within this area. For convenience there have also been marked on Plate No. 1 the epicentres of the most severe earthquakes known to have occurred in Baluchistan since 1852, this information having been obtained from the report on the Quetta earthquake of 31st May 1935, by Mr. W. D. West, M. A.

9. Interesting explanations of variations in gravity may be found in the lecture "Geophysics" by Professor O. T. Jones, in Volume 240 of the Minutes of Proceedings of the Institution of Civil Engineers.

For many years a geophysical phenomenon which puzzled scientists was that the attraction of a mountain (as measured by a plumb bob) was very much less than that expected from the density of the material comprising it.

The true explanation of the remarkable behaviour of mountains was offered by Sir G. B. Airy, the Astronomer Royal. Airy pointed out that the earth had assumed an almost correct spheroidal form, which was generally believed to be due to its having been at one time fluid or being now fluid, though having possibly a high degree of viscidity. In such a case, the strength of the crust was insufficient to support a great elevation on the surface. He remarked that on any reasonable assumption as to the thickness of the crust the weight of the mountain would break through it, and that since such elevations do in fact occur, they must somehow be supported from below. He argued that the support could only be due to a downward projection below the mountain of the light matter of the crust into a denser medium on which the crust rested. This conception that a mountain bulges downwards as well as upwards immediately accounted for the apparent defective mass of the mountain, since the attraction of the visible mountain was diminished by the smaller attraction of the invisible bulge in comparison with that of the denser medium which had been displaced by the lighter material of the mountain root. This conception, that the earth's crust is in a state of balance comparable with that of ice floes in water, is the principle of isostacy. In spite of every attempt to account for variations in the values of gravity anomalies remain. Areas where the anomalies are large and negative indicate a defect of mass in the crust below, and such areas would tend to rise, whereas those which have large positive anomalies would tend to sink.

10. The variety in types of building to be dealt with in the "safe exit" zones had made the formulation of a policy extremely difficult. Not only are the old buildings found to consist of almost every type of construction, such as brick in lime, stone in lime, brick in mud, stone in mud, mud brick faced with burnt brick, and plain sun dried brick, but some consist of combined stations and quarters, many are of defensible type with steel doors, and the whole are in every conceivable state of preservation or decay.

11. Before the earthquake of 1935 and subsequent to the earthquake of 1931, the Railway had constructed at Quetta some earthquake resisting menials quarters and five rail-framed earthquake resisting buildings (one officer's bungalow and four subordinates' bungalows) in the railway colony. These buildings withstood undamaged the disastrous shock of May 1935. In addition, there were built by the Railway, following upon the earthquakes of 1931 at stations in the area of Mach (40 miles south of Quetta) and Sharigh (587) earthquake resisting buildings of rail-framed type with plain brick in cement panels $4\frac{1}{2}''$ thick, and light roofs.

12. From Plate No. 2 it is evident that throughout the entire 542 miles of Quetta Railway Division which falls within the danger area, provision of security to occupants in one form or another has been provided by reconstruction to various earthquake standards, by strengthening, or by provision of safe exit by outward opening doors and light tied-in verandahs. Strengthening of steel structures such as tank stagings and Locomotive Sheds has been carried out where necessary and also strengthening by rail straps of buildings such as the station at Babar Kachh and some buildings at stations between Sibi and Jhatpat.

13. One of the lessons of the 1935 disaster was the danger to escaping occupants of being trapped by collapsing verandahs. This being the case, the policy has been to replace in "Safe Exit" zones as far as is reasonably practicable heavy arched type verandahs by some form of timber or rail-framed structure tied to the main wall of the building. As regards further security outside the collapsed and shaken zones all that can be done is the provision, to every room in which people work or sleep, of a door or doors opening outwards direct to the exterior.

CHAPTER III

Seismic Factor and Development of Designs.

14. In August 1935 was drawn up by the Technical Sub-Committee of the Central Quetta Reconstruction Committee a statement of general principles and rules on the design of "Earthquake Proof" buildings. These rules (the portions which are shown in small type were omitted later, see paragraph 19 below) are reproduced as Appendix I to this report.

In accordance with paragraph 3a of these rules (withdrawn later) by far the greater part of the first two seasons work on the Reconstruction Project (covering an expenditure of about rupees forty lakhs) was made in compliance with relatively costly Reinforced Cement Concrete structural frame specifications. Buildings which were not of structural frame design were of the type which later became known as "Heavy Banded," based on the 1935 New Zealand Model Building Bye-law. Some of the most marked differences between (a) the conditions of the latter and (b) those laid down by the Central Quetta Reconstruction Committee are given below, followed by comments.

15. **Seismic factor.**—(a) 0·08 G except in the case of public buildings, &c., in which case the factor is 0·1 G to 0·15 G (b) 0·125 G in all cases.

The great variation in figures of earthquake intensities (both observed and calculated), varying effects of soil, &c., make the choice of a suitable "g factor" a subject upon which there are wide differences of opinion. There are records of accelerations as high as 14 feet/Sec. 2, but the reliability of these is questionable. In Japan, Italy and California, the factor legally laid down is 0·1 G.

Mr. S. L. Kumar (see Punjab Institution of Engineers Paper No. 165) has classified regions in India under the following four heads—

(i) Areas subject to violent earthquakes, comprising certain parts of Assam, Arakan, Bengal, the area round Kangra and Mussoorie.

(ii) Areas subject to strong earthquakes, including parts of the Indo-Gangetic plain at the foot of the hills, and the extra-peninsular area (i.e., the mountainous région bordering India to the West, North and East, including Baluchistan and the hill tracks of Burma).

(iii) Areas of weak earthquake. The southern and south western parts of the Indo-Gangetic plain and Rajputana.

(iv) Areas of rare earthquakes, including the Deccan Peninsula and Ceylon.

To each class Mr. Kumar has allotted, for the purposes of design, the seismic factors given in the following table.

Class of building	Values of the seismic factor			
	Areas of violent earthquakes	Areas of strong earthquakes	Areas of weak earthquakes	Areas of rare earthquakes
A ..	0·15g	0·10g	0·05g	Nil.
B ..	0·10g	0·075g	Nil.	Nil.

As regards the choice by the Central Quetta Reconstruction Committee of a seismic factor of 0·125, points worth noting are (1) that plain brick in cement mortar buildings of small size and moderately symmetrical shape were undamaged by the disastrous earthquake of May 1935, although situated in the worst area and (2) rail framed buildings designed to a seismic factor of 0·1g with unreinforced $4\frac{1}{2}''$ thick brick in 1 :3 cement mortar panels up to eight feet long by six feet high sustained no damage whatever. In the San Francisco earthquake of 1906 a seismic force of G/3 was computed, but the statutory design factor is G/10. On page 358 of "Earthquake Damage and Earthquake Insurance" (Freeman) occurs the following opinion

"Buildings of substantial construction embouying sound engineering design will not be destroyed, nor is there likelihood of their being even seriously damaged by an earthquake of intensity equal to that experienced in San Francisco on 18th April 1906."

It is therefore reasonable to suggest that for Baluchistan the seismic factor for design should be taken in future as 0·10 g (=g/10) and 0·08 g (=g/$12\frac{1}{2}$) according to classes of buildings.

16. **Structural frames.**—See paragraph No. 209 of New Zealand Standard Model Building By-law.—"No building for public meetings shall be constructed otherwise than with a structural frame of steel or reinforced concrete."

"Provided that this requirement shall not apply to any such building which contains no room having a total floor-space exceeding 2,500 square feet in area, and of which the height of any wall does not exceed 35 feet and provided that such building complies with the restrictions as to storey height in clause 409 of this bye-law."

Paragraph 210(a) of Model Building By-law.—"No room of which the length or breadth exceeds 30 feet in a building having a height of more than one storey which is intended for use as a mental or other hospital, orphanage, hostel or otherwise for the use as an institution for young children, aged or infirm persons, or persons subject to any form of legal detention, shall be constructed otherwise than with a structural frame of steel or reinforced concrete."

For comparison see paragraph 3(a) of Appendix I. The original rules laid down by the Quetta Earthquake Committee are evidently much more conservative. It may also be noticed from a study of the New Zealand rules that some buildings there are permitted four storeys in height without the use of structural frames. On Quetta (Railway) Reconstruction works all buildings are of one storey except the combined Station and Defence Post at Shelabagh, which is a two storey Reinforced Cement Concrete structural framed type. The data used in preparing these designs are given in Appendix 2.

17. With the launching of the full program of reconstruction at Quetta, involving a seven crores program by the Military Engineering Services, and programs approximating to a crore each by the Civil and Railway Administrations, marked divergences of opinion became apparent over the question of materials and methods of construction. While M. E. S. works were executed almost entirely in reinforced cement concrete, the reinforce brick school of opinion was vigorously advocated by the Superintending Engineer (Baluchistan Civil), the principal advantages over reinforced cement concrete being economy and better insulation. Between the two extremes came the Railway, adopting reinforced brick panels and Central Reconstruction Committee requirements for use of structural frames, seismic factor, &c., as well as the "heavy banded" type referred to in paragraph 14 above. Eventually these differences became less marked, the Military Engineering Services adopting a design similar to the structural framed and brick panel type adopted by the Railway, and the Civil Administration, while adhering to reinforced brick (including vertical reinforcement) retaining reinforced concrete horizontal bands similar to those required by the New Zealand By-law.

18. As the excessive factor of safety of buildings designed to comply with all the desiderata of the Central Reconstruction Committee requirements gradually came to be recognized, economies were introduced. Among the first steps undertaken by the local Railway Engineers was the omission of the reinforced cement concrete foundation slab or raft in types Q-28 and above. The foundations are completely tied in both the framed and unframed ("banded") types by the reinforced cement concrete ribs and lower bands respectively. The next economy was the substitution of rail framed for reinforced cement concrete framed verandahs, followed by reduction in depth

of R. C. C. foundation ribs, and reduction in richness of cement mortar in plain brickwork from the 1:3 laid down in the "rules" to 1:4½ if hand mixed and 1:6 if machine mixed. Sanction was subsequently obtained to treat these ratios as nominal mixes, the corresponding field mixes being 1:3½ against 1:3, and 1:5½ against 1:4½ (no contractor used machine mixing for mortar). Further economies introduced were the reduction of the dimensions of R. C. C. foundation ribs from 12″×24″ to 12″×12″, and the increase of spacing between pairs of $\frac{3}{16}$″ horizontal reinforcing rods in brickwork from every sixth course to every twelfth course in framed buildings, and from every fourth course to every sixth course in unframed (banded) types.

19. **"Sound Pucca Specification."**—Not until the middle of the 1937-8 building season was information received (see minutes of Central Reconstruction Committee dated 18th January 1937) of any important change in the Central Reconstruction Committee rules, the changes being in the form of omissions from the original rules, see paragraph 14 *ante* and Appendix I. The most important alteration was the substitution for the rule which made obligatory the use of structural frames in certain cases, a classification of buildings into two categories, the buildings in one of which were to satisfy the seismic factor of g/8, while the others (small offices, stores workshops, &c.), were to be built " *to a sound pucca specification of burnt brick in cement mortar not weaker than 1:6*". Thus, while the majority of the original Central Reconstruction Committee requirements relating to the parts of a building being tied together, &c., were retained the use of structural frames became optional. Further decisions of the Central Reconstruction Committee laid down districts (i.e., Quetta and Chaman) where the g/8 standard should apply and others (such as Kalat and Mastung) where "sound pucca specification" would suffice.

The revised rules also permitted the use of cement sand mortar as weak as 1:6 in joints of plain brickwork, but retained the 1:3 proportion for reinforced brickwork. As already mentioned in paragraph 18 above this was treated as a nominal mix, the corresponding field mix being 1:3½.

Note.—The movement of a particle owing to a seismic wave being simple harmonic motion and the main destructive force being horizontal, the acceleration (a) can be calculated if the amplitude and period of vibration are known.

Let t=the period of one vibration (usually between 0·5 and 1·5 seconds).

Let r=the radius of the circle, or half amplitude of the quake (usually small, between ½ and 3/2 inches).

Let v = the velocity of circular motion.

Let a = the acceleration towards the centre.

Then $v = \frac{2\pi r}{t}$, and max. $a = \frac{v^2}{r} = r\left(\frac{2\pi}{t}\right)^2$

Example—

Let amplitude = 2″

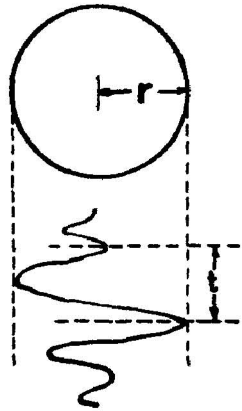
Let period = 1 Sec.

$$\text{Max. } a = \frac{2}{2}\left(\frac{2\pi}{1}\right)^2$$

$= 39{\cdot}4''/\text{Sec.}^2$

$= 3{\cdot}3'/\text{Sec.}^2$

$= g/10$ approx.

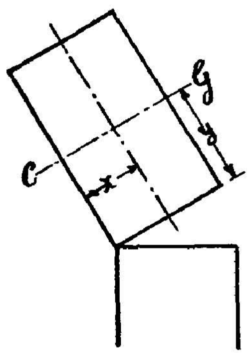


The force may also be obtained roughly from fallen objects—

$F = \frac{x}{y} W, \quad a = \frac{x}{y} g$

$F = \frac{a}{g} W$

& $a = \frac{x}{y} g$



CHAPTER IV

Unframed Buildings of the "Banded Type."

20. Arising from the modified rules the first necessity was the preparation of designs to the so called "Sound Pucca Specification", it being according to this specification that most of the remaining work in the Railway program (under the altered rules) would be carried out.

In a letter No. 275-W/24, dated 15th June 1937, from the General Manager to the Director, Civil Engineering, Railway Board, was laid down the North Western Railway interpretation of the 'cumbrous phrase "Sound Pucca Specification." Briefly the interpretation was as follows—

(i) **Cement mortar in preference to lime mortar.**—Although 1:5 was mentioned in this letter 1: 4½ hand mixed continued to be used until sanction was obtained to treating this as a nominal mix, the corresponding field mix of 1:5½ being thereafter standardized. 1:6 mortar was not used on Railway buildings.

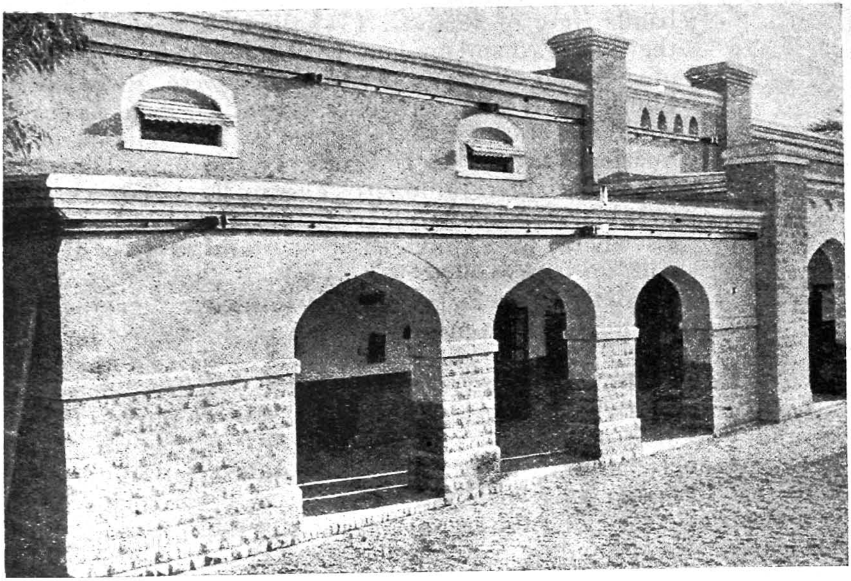
(ii) **For flat roofs R. C. C. Slabs.**—R. C. C. slabs were largely used at Sibi, (one of the hottest places on earth) but the special hollow brick &c., insulation necessitated thereby rendered them more expensive and no cooler than a sawn sleeper and mud covering type. Termites are not a problem at Sibi owing to the drought and excessive heat. In the cool areas, roofs of C. I. sheets and sawn sleepers on rail beams or trusses were used.

(iii) **Wall thickness to be reduced from 13½″ to 9″ if a banded type is adopted.**—The Railway banded type was framed on the New Zealand by-law. Thus in the Railway banded type the height of 9″ thick walls has ordinarily been limited to 10′ and there are R. C. bands at plinth, lintel, and eaves. The New Zealand rules specify metal bonding at every fourth course of brick-work and additional bonding below window sills and above lintels, but do not specify R. C. C. bands at lintels and eaves such as have been provided in the railway banded type, compensated by slightly greater spacing of metal bonding in the walls. In the Railway interpretation of "Sound Pucca Specification" the same limit of 10′ in height for 9″ thick walls has in most cases been adhered to as in the pre-January 1937 banded type, but metal bonding between courses of brickwork has been omitted.

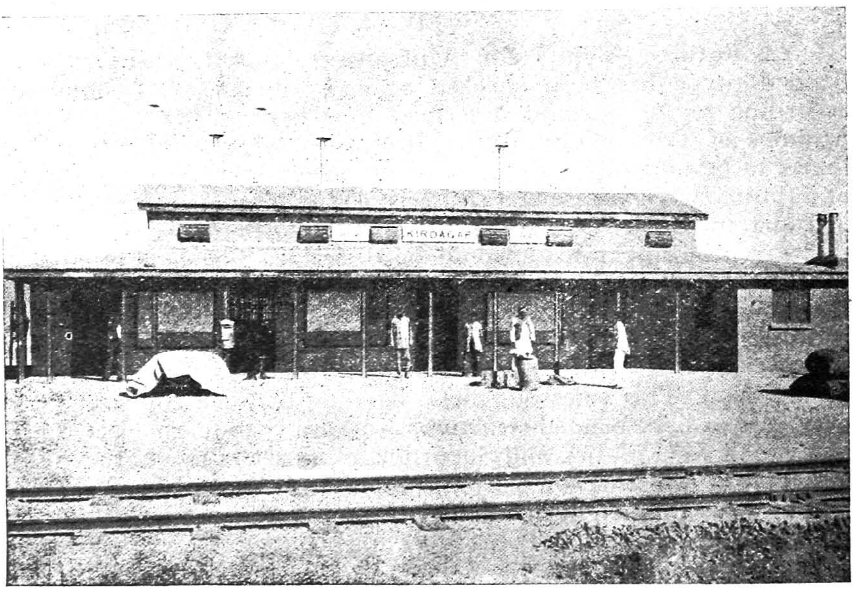
(iv) **Reinforced Bands.**—In the Railway banded type the bands were of R. C. C. $13\frac{1}{2}''$ thick, in accordance with the New Zealand by-law. In the Railway interpretation of "Sound Pucca Specification" were included the plinth band and top (eaves) band (which serves the additional purpose of an anchor to the roof) in menials quarters and all three bands, i.e., at eaves, lintel and floor in larger buildings. Eventually R. C. C. bands (9" thick for rooms up to 20' in length and $13\frac{1}{2}''$ thick elsewhere) were provided at floor and eaves in all cases with an intermediate R. C. or R. B. band (two rods $\frac{3}{16}''$ diameter in menials quarters) formed by making lintels reinforcement continuous.

21. **Heavy Banded and Light Banded.**—It may have been gathered from the above description that the Railway interpretation of "Sound Pucca Specification" goes a good deal further in its anti-seismic characteristics than the name indicates, practically the only difference from banded type buildings built in accordance with the New Zealand code being the use of lighter (but more) bands, and the omission of metal bonding between courses of brickwork except in the case of the reinforced brickwork bands at lintels. For simplicity the name "heavy banded" has been adopted to describe unframed metal-bonded buildings built in the early stages of the project and the name "light banded" to describe the later and more economical type.

22. **Future Type for Unframed Buildings.**—The "light banded" type has been checked against a horizontal force of g/8 according to the method described by Cherry in Vol. 236 of the Minutes of Proceedings of the Institution of Civil Engineers and found to be much over strength. It can safely be adopted as the basis of a future type of unframed anti-seismic building for earthquake areas in India, in which case a specification in the form of a simplification of that given at Appendix I would be desirable. The new type should contain some vertical reinforcement to ensure its "box" characteristics and to resist possible uplift effects and sudden shocks of the hammer blow variety even though theoretically unnecessary. All reinforcement should be so placed as to avoid possibility of fraud by its omission. This rules out metal bonding between courses. Typical examples of light banded structures are Yaru Station, menials quarters in a cool area (Kolpur), and Subordinates' quarters in a hot area (Sibi, drawings of which accompany this report, see Plates Nos. 3, 4 and 5). In hot areas the height of rooms is from one to two feet greater than that of corresponding cool area types and the room areas are greater.



Rail strapping to a station building (there are tie-bars through the building to rail straps at back.)



A "Light Banded" type of anti-seismic building.

Note.—Asbestos cement chimneys and light rail framed verandah and light roof.

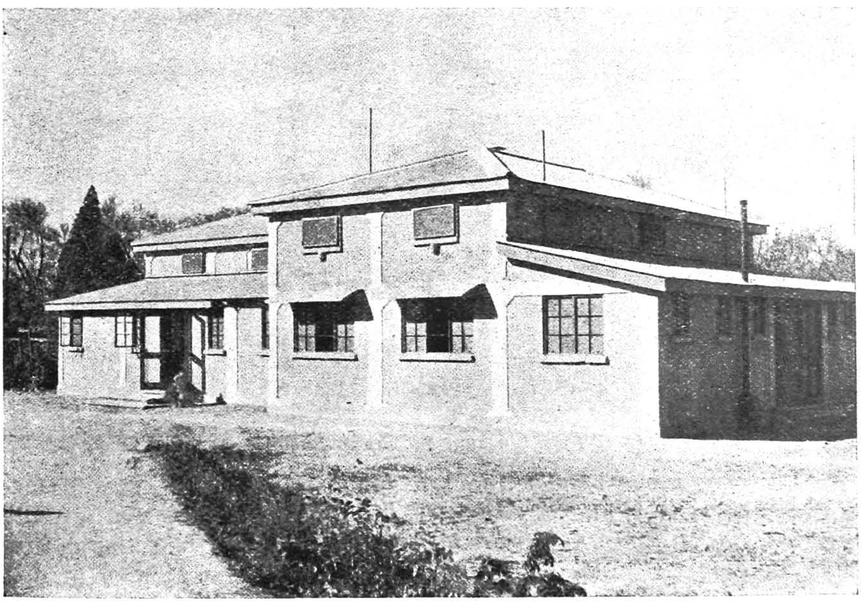
CHAPTER V

Structural Framed Buildings

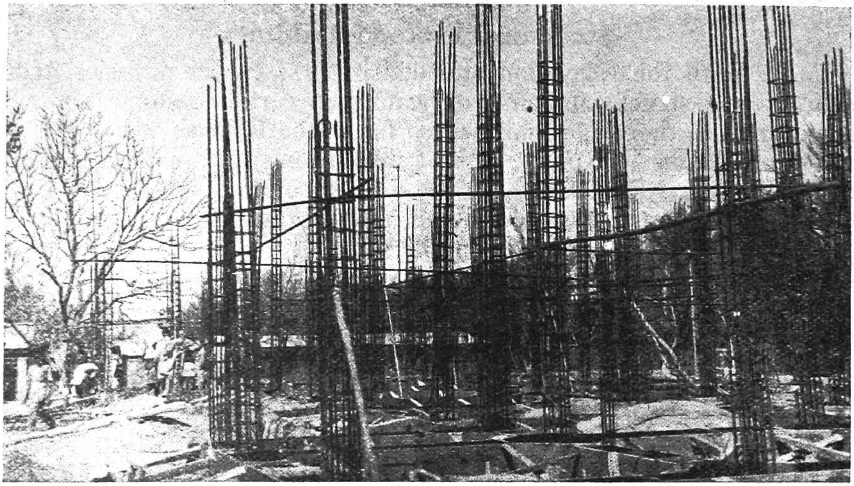
23. With the relaxation afforded in 1937 by the omission of the rule making structural frames obligatory in certain cases this type of structure was thereafter confined so far as the Railway was concerned to large buildings or (in the case of steel frames) to buildings designed to use up salvaged material. In the former category are the Divisional Office, the Railway Station, the Intermediate and Third Class Waiting Hall, and Officers Bungalows. Information of the relaxation not having been received until June 1937 (by which time work on the 1937 season's program was too far advanced to be radically changed) all permanent quarters for staff drawing Rs. 65 p. m. and above at Quetta are of the framed type.

24. **Length of units.**—As regards menials quarters it was found more economical to build structural framed blocks containing a dozen or so units than to use the banded type limited as it then was to blocks of four units by the 800 square feet rule (see item 3(a), Appendix 1). The multi unit blocks so built violate to some extent the anti-seismic principle of length not greatly exceeding breadth, but this defect is amply covered by the high factor of safety in the R. C. framed type.

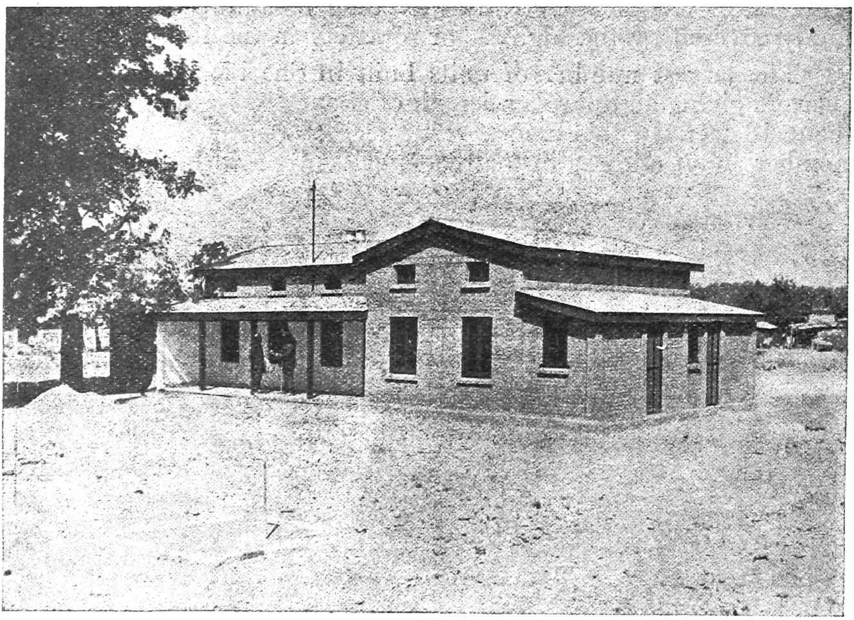
The largest number of units built in one block was 14 menials quarters giving an unbroken length of about 150 feet and a breadth of about 18 feet. In this case a vertical crack occurred in a horizontal member about midway in the block, evidently a shrinkage crack.



Assistant Divisional Officer's Bungalow at Quetta.



Column reinforcement for A. D. O.'s Bungalow.



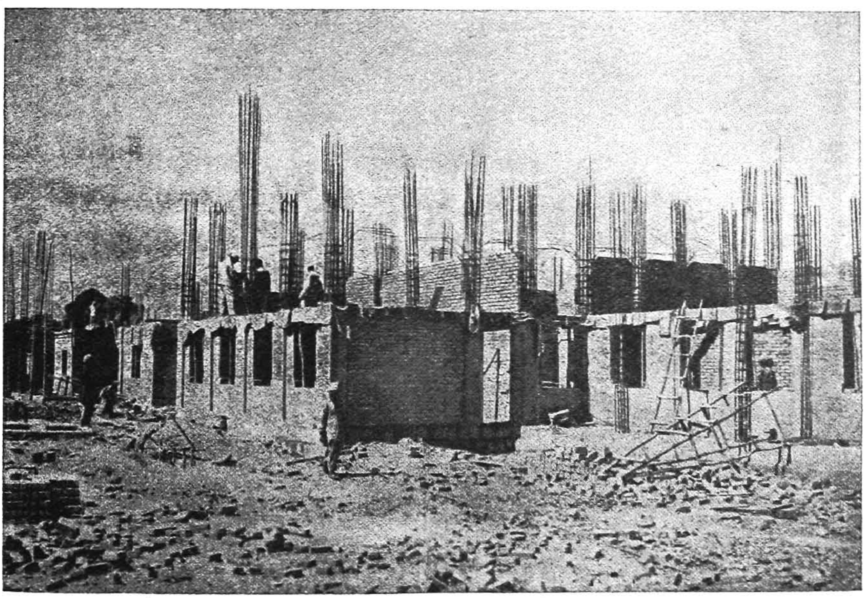
Q-32 Type Quarters for Senior Subordinates.

The next longest single block is a length of approximately 102 feet in the Station Building (breadth 32 feet). Not in this or in any other long monolithic R. C. frame forming a separate block in a large building have cracks occurred. Plate No 7 shows the position of planes of weakness ("crumple sections") introduced in large buildings for anti-seismic and anti-shrinkage and temperature effect reasons. At these points there is a space of about seven inches between the end frames of the blocks into which the building is thus separated, a distance which is sufficient in single storey buildings to prevent mutual battering in a severe earthquake. These breaks are masked inside and out by light material such as asbestos cement sheets.

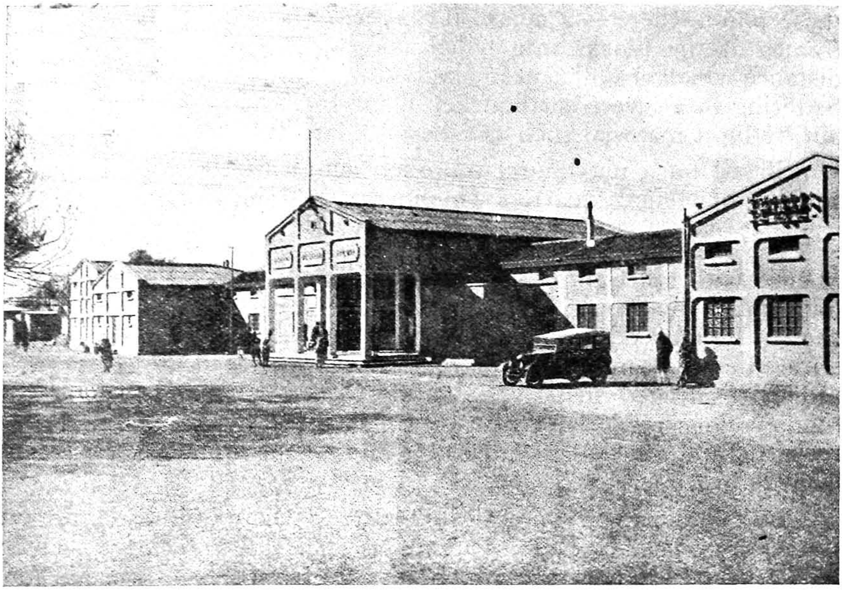
Based on a maximum unbroken length of 100 feet the greatest number of menials quarters which could be built in one block is nine.

25. **Design data.**—The work of designing buildings in compliance with the Central Quetta Reconstruction Committee rules was undertaken by Mr. G. C. Trehan. Preliminary calculations having shown Reinforced Cement Concrete to be cheaper than concrete encased steel beams the latter were not further considered except for utilizing salvaged material. The data then adopted, together with modifications made later to conform to the I. S. R. Code of Practice for structural steel work, and a note on fixing assumptions for columns is given in Appendix 2.

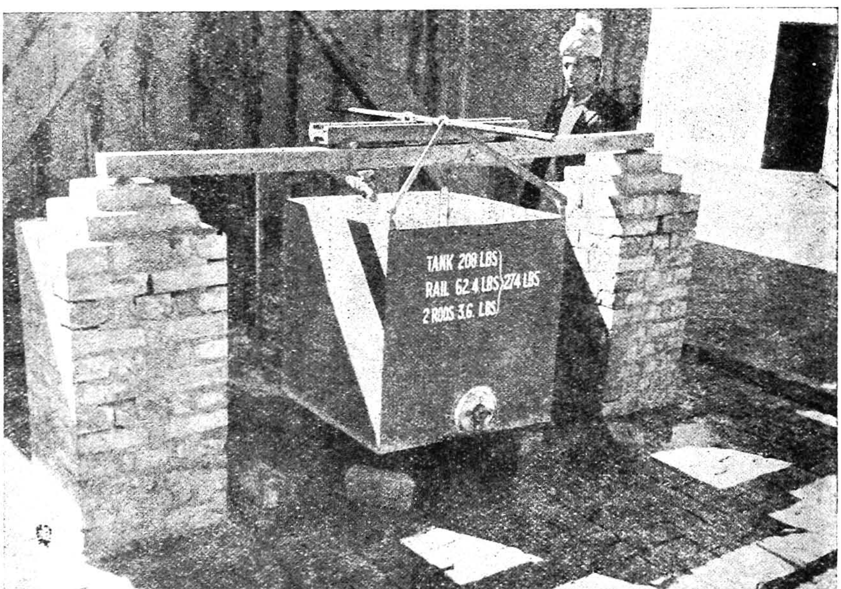
Calculations were complicated in cases where rigid R. C. verandah frames were used (see item 7, Appendix 2). This difficulty was solved by the use of rail framed verandahs which reacted to seismic forces independently of the main building. This design (see Plate No. 13) being neat, inexpensive and workmanlike, became standard. A design of typical of R. C. C. framed type is that of an Assistant Officer's bungalow shown at Plate No. 9.



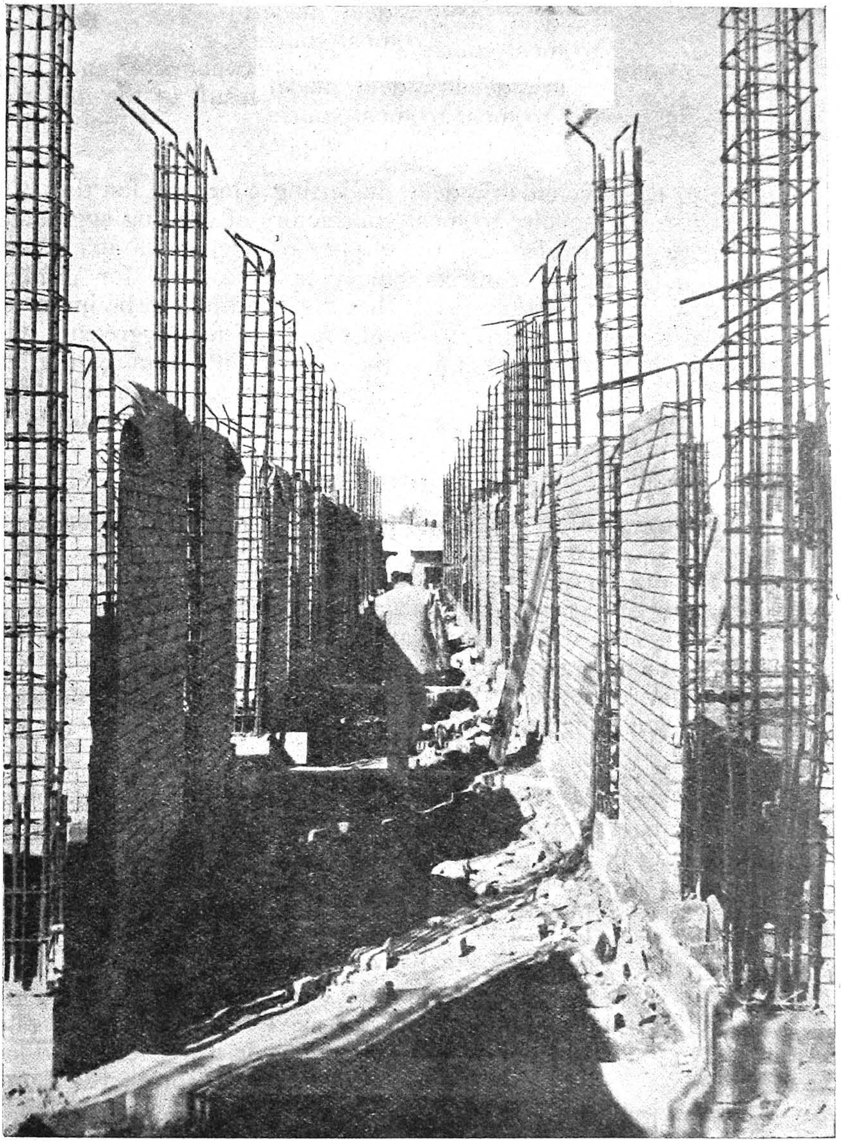
Quetta Station Building in course of construction.



Quetta station building completed.



Beam test for concrete.



Divisional Office, Quetta, in course of construction.

CHAPTER VI

Proportioning Concrete and Economies in use of Cement

26. Up-to-date methods for obtaining economical and high strength cement concrete were introduced as a result of the initiative of Mr. E. Catley.

Owing to the unavoidable delay in letting contracts for the 1936 program and to the novelty to most contractors of grading aggregates it was necessary to arrange for the supply of aggregates apart from the main reconstruction contract. Early specifications for grading were not satisfactory, with the result that fine sand had to be imported from Saranan for mixing with the local supply of fine aggregate. The problem of testing concrete was first met by sending compression test cubes to the M. E. S. laboratory. The results varied considerably and showed that the concrete was more often than not, very much over strength.

27. **Use of graded aggregates.**—Late in 1936, samples of aggregates were collected from various sources in Quetta and sieve analysed. The results of these tests were most satisfactory and proved that the grading of natural aggregates obtainable from torrent beds in the vicinity of Quetta was approximately the same as that laid down in the I. R. S. Code of Practice for R. C. This led to the adoption of new specifications for aggregates to be supplied for 1937 and the succeeding years of reconstruction.

Thus was proved at the outset to be non-existent one of the main supposed drawbacks to the use of graded aggregates, namely, the necessity of screening to all the intermediate gauge sizes. Naturally-graded aggregates proved after search and analysis to be available in abundance. For grading specification see Appendix 4.

28. Meanwhile the necessity for a Railway laboratory arose, and before the end of 1936, apparatus for the sieve analysis of aggregates and for the testing of cement and cement mortar had been provided. The difficulty of testing concrete was solved by adopting the Bundi Beam Test (Appendix 3) obtained from the Concrete Association of India. Early in 1937 concrete mixes were designed on the Fineness Modulus Method and based on the water cement ratio adopted from "Modern Methods of Concrete Making" by A. E. Winn, B. SC., A.M., AM. SOC., C.E., and Ewart S. Andres, B. SC., M.I.C.E., Appendix B (see also "Controlled Concrete" Technical Paper No. 291 by A. W. Cripps Villiers).

The aggregates used were according to the Specification attached as Appendix 4 and the combined fineness moduli for concrete were taken as—

5·4 to 5·7 for 1½″ concrete (Plain).

5·2 to 5·5 for ¾″ concrete (ordinary R.C.)

4·4 to 4·6 for ½″ concrete (R.C.C. for columns and thin Sections).

29. For plain concrete for use in foundations a start was made with eight gallons of water per cubic foot (90 lb.) of cement and this was gradually increased to 11 gallons per cubic foot. The resultant decrease in equivalent cylinder strengths per square inch at seven days was from 2,360 lb. to 1,160 lb. and at 28 days from 4,078 lb. to 3,480 lb. The minimum cylinder strength required was fixed at 900 lb. per square inch at seven days. The average proportions for plain concrete with 1½″ coarse aggregate and coarse sand, poured in 1937 were—

Real Mix	..	1:12.
Nominal Mix	..	1:4½:9¾.
Field Mix	..	1:4⅞:11.
Slump	..	0″-2″

For Reinforced Concrete a start was made with seven gallons of water per cubic foot (90 lb.) of cement and this gradually increased to eight gallons per cubic foot. The resultant decrease in equivalent cylinder strength per square inch at seven days was from 4,500 lb. to 2,500 lb. and at 28 days from 5,970 lb. to 3,840 lb. The minimum seven days cylinder strength for 1:2:4 nominal mix ordinary grade concrete is 1,200 lb. per square inch as given in Table 1 on page 7 of the I. R. S. Code. The average proportions for concrete with ¾″ coarse aggregate and coarse sand poured in 1937 for normal sections, were—

Real Mix	..	1:7·03.
Nominal Mix	..	1:2⅓:4⅞.
Field Mix	..	1:2¾:6½.
Slump	..	2″ to 4″.

(2″ notified to contractors).

The average proportion for concrete with ½″ coarse aggregate and fine sand poured in 1937 for columns and thin sections were—

Real Mix	..	1:6·22.
Nominal Mix	..	1:2⅓:4⅞.
Field Mix	..	1:2⅞:5⅜.
Slump	..	4″ to 6″.

(2″ notified to contractors).

Minimum cylinder strength at 7 days	..	1,200 lb.
Minimum cylinder strength at 28 days	..	1,800 lb.

The quantities of water given above include those contained in the fine aggregate (Coarse aggregate was always found to be dry). Frequent weighment tests were made to ascertain the water content of "Sand," the resultant quantities being deducted from those given above for arriving at the amount of water to be added to the "dry" mix.

The old haphazard proportions for the three kinds of concrete used were 1:3:6, 1:2:4 and 1:1⅔:3⅓ respectively. The resulting economies in cement, obtained by designing the mixes according to the method described and adopting modern methods, are 30 per cent approximately. For method of tabulating the test results, see Plate No. 12 and Appendix 3.

30. At the commencement of the 1937 season, mixes were designed in accordance with the detailed instructions at Appendix 5, for every new supply of aggregate, and included—

Sieve analyses,
Bulking, and
Shrinkage Factor.

Later, owing to absence of rain and the consequent dryness of the aggregates, tests for bulking and shrinkage factor were to some extent dispensed with as these were found to be—

Bulking for sand	..	12·5 per cent (dry) to 35 per cent (damp).
Bulking for aggregate	..	14·0 per cent to 20 per cent.
Shrinkagefactor	..	85 per cent to 90 per cent.

Sieve analysis has been carried out on all samples, firstly to ensure that the materials were supplied in accordance with the specification and secondly for proportioning by the formula—(see Appendix 5).

$$r = \frac{M_a - M}{M_a - M_s} \times 100 \Rightarrow \text{percentage of sand.}$$

31. **Mortar tests.**—Concrete and mortar were tested daily on every work to ensure that the requisite strengths were maintained. For standard mortar of sand and cement, briquettes were made from the mortar as used by the masons on the work and these were broken at seven days and 28 days. For the standard nominal mix of 1:4½ (field mix≑1:5·4) the required 28 days tensile strength was taken as 400 lb. to 600 lb./sq. inch, and it was found from the average of several hundred routine tensile works tests of mortar briquettes that—

(i) Strength was within the required limits in 89·89 per cent.

(ii) Strength above normal—7·32 per cent.

(iii) Strength below normal—5·56 per cent.

The lowest recorded figure was 276 lb./in.^{2} for mortar used in a boundary wall, a figure which is, however, far in excess of that used in design.

32. **Concrete tests.**—For the concrete tests six test beams were cast in the presence of the subordinate in change (for every mix) for every day's concreting on each job and of these, three were broken at seven days and three at 28 days. The beams were broken by loading them with a tank which was gradually filled with water.

The apparatus in the Reconstruction laboratory included a briquette tensile testing machine, a set of standard sieves, two balance scales with weights, a "Vicat" apparatus for cement, and three tanks, all provided for less than Rs. 2,000. The extra staff included one S. I. W. and five Khalasis, the cost of which is about Rs. 150 per mensem.

33. **Conclusions.**—The main conclusions reached in Quetta are—

(i) Water must be rigidly controlled and checked by frequent "slump" tests.

(ii) Good grading of aggregates is a potential source of great economies in cement. The cost of grading is not high. In the case of natural aggregates, deposits are usually found to contain the requisite grading. The same applies to crushed aggregates, little screening being required in either case.

(iii) In order not to remove all the fine content in sand, washing (if ordered) must be carried out with caution. Test results show that it is not necessary that aggregates should be absolutely clean. The figures given in the I. R. S. Code of Practice are as follows—

(1) Silt removable on decantation not to exceed three per cent.

(2) In fine aggregate the maximum passing a 100 sieve—five per cent.

(3) Field test. Silt, loam and clay not to exceed six per cent.

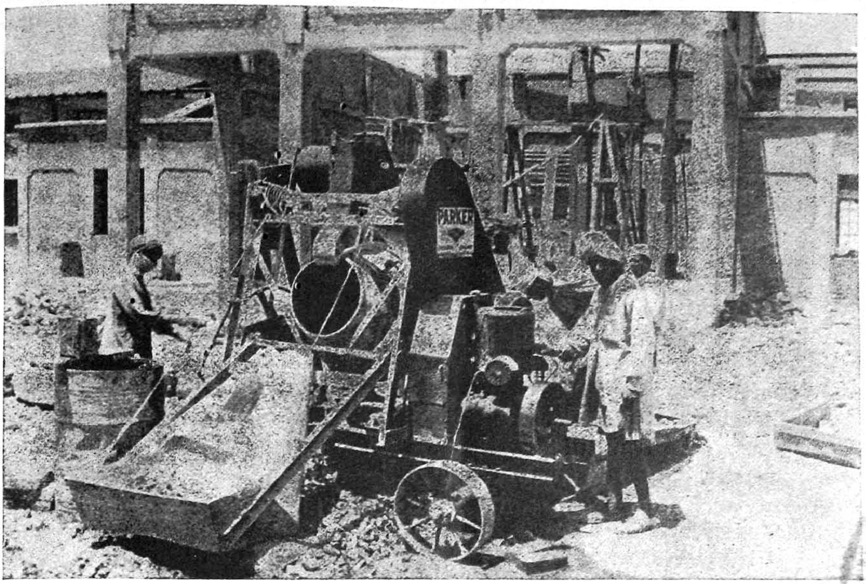
On Quetta Reconstruction, mortar tests having shown that a moderate excess of clean clay silt did not affect the strength, while insistence on the Code of Practice percentages led to excessive cost in obtaining sand, six per cent silt was permitted.

(iv) Machine mixing is essential if high grade standards are to be applied. Excellent machines are available at small cost, and the extra cost of machine mixing is negligible.

(v) To deal with the habit of workmen and others of applying plaster to conceal defective concrete, plaster on concrete was forbidden. Standing orders were that no concrete was to be touched until it had been inspected by an Assistant Engineer after removal of the forms. Evidences of sound concrete are visible marks of forms on the completed work, unsightly though these may sometimes be. It was not until contractors were made to pay the penalty of destruction and replacement at their cost of concrete which had been "touched up" before being inspected and passed by the Assistant Engineer that they took the trouble to rod and work concrete properly.

(vi) Far weaker mixes than are normally specified can safely be used. For plain concrete in foundations a 1:9:16 field mix was found to have a 28 days cylinder strength of 900 lb. per square inch.

(vii) Brief experience with modern methods of proportioning concrete is sufficient to prove that the extra strength obtained by the use of high grade and special grade concretes more than counter-balances the extra cost of



Six cubic feet mixer.

Small portable mixer.

graded aggregates and testing. On Quetta Reconstruction the work was not carried out "under the immediate and continuous supervision of a gazetted officer," but under the alternative conditions laid down in paragraph 9(c)(ii), page 4 of the I. R. S. Code of Practice, namely, "where the work is carried out in an organized depot under the general supervision of an officer the continuous supervision need only be exercised by a qualified subordinate."

34. **Cessation of practice of issuing free cement and steel.**—Under the North Western Railway system of free issue of cement and reinforcing steel to contractors there are open two sources of fraud, firstly the drawing of excess quantities and fraudulent disposal thereof (including cut ends of steel rods), and secondly starving the concrete of cement and fraudulent disposal of the balance. Alternatively, grossly extravagant mixtures calculated on nominal mixes are used. If cement and steel from railway stocks were issued to contractors and the cost recovered at a fixed figure in excess of market rates the second of these two sources of fraudulent disposal would alone remain, and this can be met by strength tests.

In the course of Quetta Reconstruction many rates (prices) for reinforced concrete have been derived. The excessively high rates obtained in 1936 before contractors settled down to do the work economically have been discarded and new sets of rates for all labour and material in reinforced concrete of structural framed buildings have been obtained for incorporation in the North Western Railway Schedule of Rates. Schedule items should, however, include rates for separate supply of graded aggregates, experience having shown that it is usually necessary to centralize supply of these. If cement and steel are to be provided from railway stocks the cost to be recovered from contractors (which should be stated in the tender document) should (for obvious reasons) be slightly higher than public market rates, the cost of works being credited with the difference between the amount recovered and the lower cost to the railway owing to lower transport charges.

35. **Quantities of Cement required in various mixes of concrete and mortar.**—Whatever be the system of providing cement for works it is of great importance that both estimating and supervising staff should know the quantities of cement actually required for various proportions of concrete or mortar as specified for the work. These can be calculated from the figures of real or field mixes or read from graphs such as those on pages 34, 35 of "Controlled Concrete" (Technical Paper No. 291). Based on a one hundredweight bag of cement

containing 110 lb. (2 lb. for the sack), and weighing 90 lb. a cubic foot, the following are typical figures for graded sand and aggregates of 1½" maximum size downwards.

Cement required for 100 cubic feet of finished concrete—

Real mix ..	1:5·1 to 1:5·5.
Nominal mix ..	1:2:4.
Field mix ..	1:2¼:4½ } 1:2¾:4½
Cement required..	14 bags. (¾" aggregate).
Real mix ..	1:7·65 to 1:7·8
Nominal mix ..	1:3:6
Field mix ..	1:3½:7 } 1:4:7
Cement required..	10 bags. (1½" aggregate).
Real mix ..	1:10·2 to 1:10·5
Nominal mix ..	1:4:8
Field mix ..	1:4½:9 } 1:5½:9
Cement required..	7·5 bags. (1½" aggregate).

The above figures which are based on quantities actually used in controlled works correspond to the bulking and shrinkage factors given at paragraph 30 *ante*. They are approximate to the extent that these factors vary for different aggregates and water contents.

On Quetta Reconstruction the system was introduced of applying the principles of bulking percentages to sand-cement mortars as well as to concrete. It is obvious that with moist sand "bulking" by as much as 35 per cent, there may be gross extravagance in applying the nominal proportions to field mixes. In the following example the quantities of cement are those necessary to give the requisite proportions on the reduced dry-rodded volume of sand and it is to these field mix ratios that mortars should be mixed. The following figures which are based on actual works will be found useful.

Cement required for 25 c. ft. of Mortar in 100 c. ft. of Brick Masonry

Nominal mix.	Corresponding field mix. (bulking taken as 20 per cent)	Bags of cement required for mortar in 100 c. ft. of masonry
1:3	1:3·6	6
1:4½	1:5·4	4
1:5	1:6	3¾
1:6	1:7·2	3½

The strengths obtained from mortar mixed to the above "field mix" ratios under control of water and of fineness modulus, &c., of sand greatly exceed the strengths allowed in design (*vide* paragraph 31) and give a saving in cement of 17 per cent to 20 per cent.

36. **Effect of curing time on strength.**—The period laid down in the I. R. S. Code of Practice is 28 days. Experiments were made on the effects of curing for much shorter periods, the test beam, which was only $3\frac{1}{2}'' \times 2\frac{3}{4}''$ in section, being exposed to the sun in September.

Test beam $3\frac{1}{2}'' \times 2\frac{3}{4}''$ Field mix.=1: 2·52: 5·1 Real mix.=1: 5·8 Water=7 gallons per C. ft. of cement	Cylinder strength after 7 days	Cylinder strength after 28 days
Required strength	1200	1800—3600
7 days curing	1692	....
7 ,, ,, and 21 days in hot sun	....	2588
14 ,, ,, ,, 14 ,, ,, ,, ..	....	2700
21 ,, ,, ,, 7 ,, ,, ,, ..	....	2588
28 ,, ,, ,, 0 ,, ,, ,, ..	....	2773

The conclusion is that 14 days curing is sufficient for slabs and small structural members, and that for large section members the curing time could be further reduced.

37. **Effect of pouring large roof Slabs in a continuous operation without contraction joints.**—The slabs were four inches thick, reinforced with $\frac{3}{8}''$ diameter rods at 5″ centres and $\frac{1}{4}''$ diameter distributing rods at 12″ centres, cast integral with T beams at 9′-4″ centres. The nominal mix was 1: 2: 4 (field mix 1: $2\frac{1}{2}$: $4\frac{1}{2}$, using 14 bags of cement for 100 cubic feet of concrete).

The largest slab so poured measured 36′-6″×101′-5″. After curing for 28 days it was allowed to dry out for about a month and a half in the intense heat of the direct rays of the sun at Sibi, after which it was covered with the hollow bricks and clay of the roof insulating material. No cracks became visible at any time and though the roof was later saturated by heavy rain which penetrated and washed away the clay covering, no leaks occurred in this or in any of the dozen or so similar roofs.

38. **Experiments on the protection of cement concrete from sulphate concentrations.**—The portion of buildings subject to concentrations of destructive salts is only that near the ground, in the case of Earthquake resisting buildings up to and including the lower band or rib according to type.

Aluminous cement.—Aluminous cement is immune from attack by magnesium salts and sulphates but it is between two and three times as costly as Portland cement. A less costly preventative is desirable.

Pozzolanas.—When Portland cement sets, free lime is liberated. Pozzolanas are calcined materials such as volcanic ashes, blast furnace slag, burnt clay or bricks, &c., which, combined with this lime, produce a concrete better able to resist the action of many destructive agencies. An obvious 'pozzolana' (this was used on the Sennar Dam) to use in India is finely pulverized well burnt brick, or "surkhi."

The tests were made after immersing (after seven days curing) briquettes made with different puzzolana contents in a concentrated liquor obtained by dissolving soil encrustations in water, and comparing the tensile test results with those obtained from briquettes cured for a similar time (12 weeks) in clean water.

Proportion by weight of ingredients of briquettes			Percentage strength of briquettes cured in sulphate liquor compared with strength of those cured in clean water
Cement	Surkhi	Sand	
1	0·3	2·7	21 per cent
1	0·6	2·4	29 per cent

The loss in strength in such a severe test as this was of course enormous (cement being soluble in the solution) but there is a clear gain by substitution of a proportion of the sand by "surkhi."

On Quetta Reconstruction foundation masonry of buildings in the sulphate soil near the railway station was made of hard limestone and (as a result of the experiments) surkhi was mixed in the ratio 1:0·6: 2·4 in the mortar of the stone masonry below the lower concrete band. In the lower band itself two inches was the minimum concrete cover allowed over the steel on the outside of the building.

39. **General note on the use of Concrete.**—Although concrete is an excellent building material, both strong and (under proper control) economical, it must be borne in mind that it is a bad material for protection against heat or cold. This does not debar its use in foundations, but in super-structures it should be used with caution, and if used for roofs special care is necessary to ensure that it is waterproof and that it is insulated against extremes of temperatue. For an example of heat insulation of R. C. C. slab roofs in Sibi (than which probably no hotter station exists in India) see paragraph 57.

CHAPTER VII

Semi-Permanent Types

40. In addition to permanent types of buildings a "semi-permanent" type was evolved. Under the rules laid down in the State Railway Code, railway staff are not necessarily provided by the Administration with railway quarters, but those whom it is essential to house near their work (essential staff), and in any case where local enterprise does not provide the necessary facilities, railway quarters may be provided, even for "non-essential" staff, i.e., those whom it is not essential to house near the site of their work.

41. In accordance with this policy a so called "semi-permanent" type of dwelling has been evolved for non-essential staff resident at Quetta. At out-stations (where there are practically no facilities for housing by local enterprise) accommodation has had to be provided by the railway for all staff, permanent for permanent employees and semi-permanent for others, such as extra fruit traffic staff. For menials at out-stations, and for wayside gangmen (whose residence in railway quarters is very difficult to enforce) provision has been made at a nominal ratio of 67 per cent, the actual ratio of units of quarters to numbers of menials for all out-stations being for various reasons a good deal higher than this figure. At Quetta itself the provision of menials quarters is about 100 per cent, of which about 15 per cent are semi-permanent.

42. Drawings of a semi-permanent type of quarters consisting of old rails and unserviceable sleepers for cool areas are at Plate No. 6. In place of the normal procedure in sleeper quarters construction of burying one end of the sleeper walls in the ground and so losing some much needed height, a simple trough foundation is made, consisting of a base obtained by sawing ten inch by five inch sleepers into five inch by five inch sections and bolting to each side of the base, pairs of timbers obtained by sawing sleepers into pairs of $10'' \times 2\frac{1}{2}''$ planks. The trough so formed is laid on a brick plinth nine inches above ground level and into it are bolted the ends of the vertical sleepers. All the trough timbers and the lower ends of the vertical sleepers are immersed in hot tar after cutting, and before bolting together. It will be noticed that by this method of cutting there is no waste except the thickness of the saw cut.

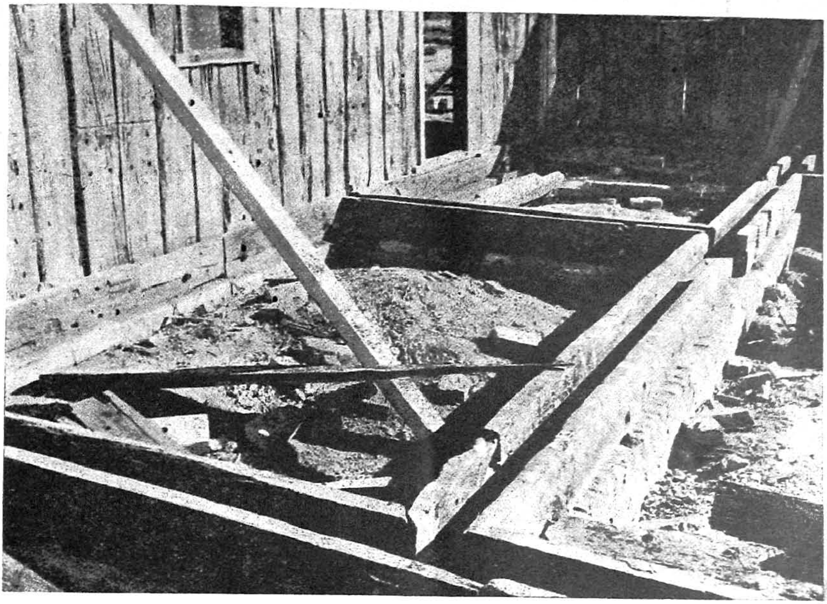
43. An essential feature of earthquake-resisting design is the tying of the roof to the walls. To achieve this result, to the rail beams on which the roof is carried are bolted on each side of the web robust wooden strips, the half-sawn sleeper roof planks being securely nailed to these strips at one end, and to the wall runners (themselves bolted to the wall sleeper ends) at the other end. These, the diagonal bracing,

and the metal corner straps, practically convert the building into a box. By using bolts the building is made portable. Thus the officers' semi-permanent huts, replaced by permanent quarters, have been dismantled and re-erected in replacement of unsafe masonry rest-houses, &c. Similarly, surplus menials temporary quarters have been dismantled and re-erected as out-houses.

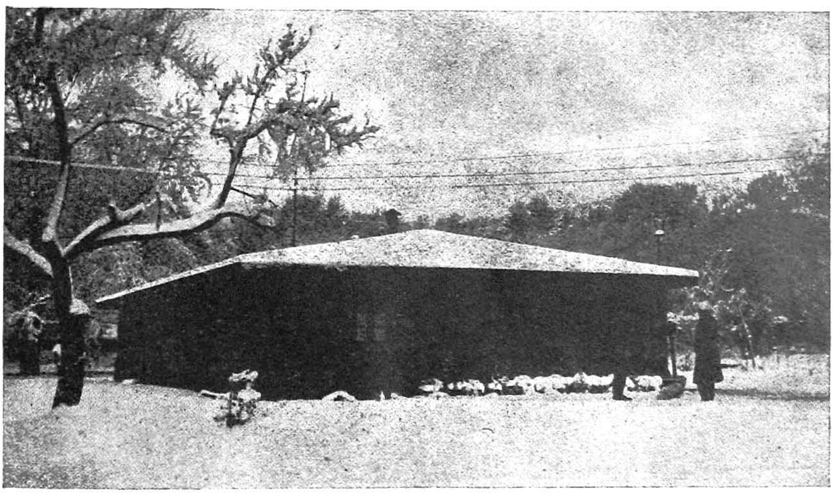
To guard against fire risk, the kitchens are built in brick, and flue pipes (if of metal) are taken through the roof in a gland consisting of asbestos rope wrapping and a four inch wide annulus of clay between asbestos cement discs. For the standard flue pipe of asbestos cement no insulation is necessary.

44. For waterproofing and insulating the sawn sleepers of the roof many experiments, involving tarred fabric and tarred mud, were made and all were abandoned in favour of corrugated iron in cool areas and rammed mud in hot areas. For plugging cracks between wall sleepers the most satisfactory method was found to be by plugging with clay and then nailing $\frac{1}{2}''$ thick wooden strips along the joints on the outer side of walls. An adaptation of the semi-permanent type is that shown in Plate No. 8, where a masonry sub-wall gives the additional headroom necessary in hot areas. A further amenity provided in the hot area S. P. type is an increase in the area of the main room from 100 square feet to 120 square feet. Although semi-permanent quarters cost only about two-thirds of the cost of permanent quarters they are so sought after that in regions of excessive heat such as that between Sibi and Jacobabad there is competition for their allotment.

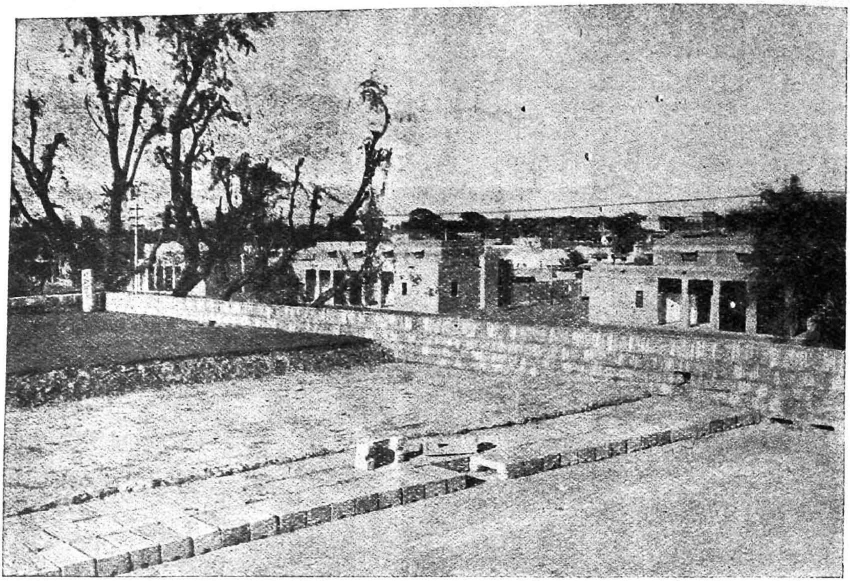
45. The semi-permanent type (of which over 500 have been built) has proved very successful. It is cheap (Rs. 2-4-0 per square foot for cool area menials type, and Rs. 3 per square foot for hot areas type) cool in hot weather and warm in cold weather. If no longer required at one site it can (owing to the use wherever possible of bolts in place of nails) be dismantled and re-erected elsewhere with practically no wastage except the loss of the plinth, and when it finally decays the materials serve for firewood. Termites not being a serious problem in either the cool or hot regions on Quetta Division the life of semi-permanent buildings has been taken as about 25 years, a conservative figure. With $2\frac{1}{2}$ feet high masonry in lime or cement mortar sub-walls and full immersion of sleepers in tar after cutting, the type is suitable for use thoughout the North Western Railway system.



Foundation troughs for semi-permanent building.



A completed semi-permanent officers hut at Quetta.



Detail of half hollow brick and mud insulation over R. C. C. slab roofs at Sibi.

1″ thick mud plaster.
4″ thick rammed mud.
1″ thick mud plaster.
Half-hollow bricks laid dry.
Half-hollow bricks in parapet (closed with wire gauze).
4″ thick R. C. C. slab on T beams.

CHAPTER VIII

Modern Sanitary Installation

46. **Justification of the Quetta Scheme.**—Before the 1935 Earthquake the system of drainage and sewage disposal was by trenching, incineration and sullage carts. From calculations made by the specialist attached to the Local Quetta Reconstruction Committee, it was found that modern sanitary installation would be financially justifiable. Sullage water has been included in the scheme so that it may help to flush out the drains, but storm water has been excluded.

47. The calculations of the sizes of pipes have been made on the assumption that all tap water supplied will enter the drainage system. The consumption of water per head per day in the Railway Colony at Quetta has been taken as 40 gallons for officers and 25 gallons for subordinates and menials. The sewers are designed to flow half to two-third full. This affords a reasonable factor of safety to provide against extentions to the scheme.

48. Samples of sub-soil water were examined in the Government Food Laboratory at Kasauli and the results showed presence of sulphates. The use of Portland cement concrete pipes in the saturated area was, therefore, ruled out, being susceptible to attack by sulphate and other salts Secondly, the areas suffering the greatest damage in the 1935 Earthquake are liable to the greatest amplitude owing to the high level of sub-soil water and the lower resistance of the soil. Pipes in the saturated area should, therefore, be more able to resist ground movements than those in the dry stony soil.

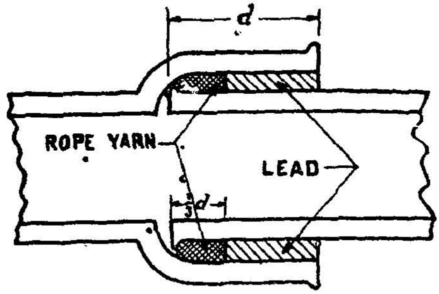
From the very limited literature on the subject the pipe lines in the order of immunity from seismic forces are—

(i) Steel
(ii) Cast iron
(iii) Concrete
(iv) Earthenware.

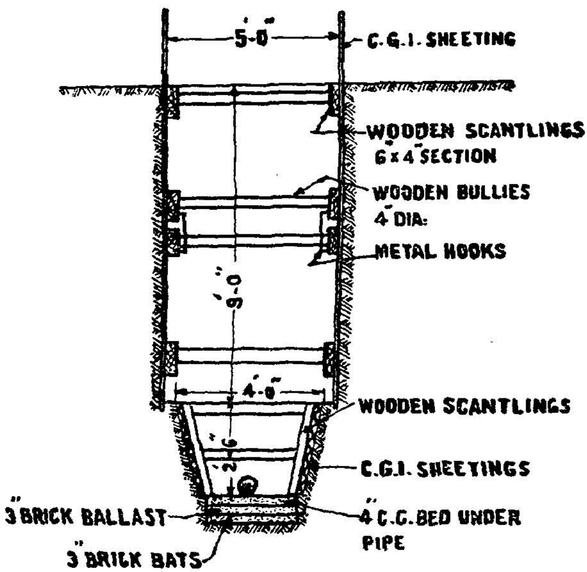
Furthermore, there is ample proof that cement is attacked by sewer fluids and gases. Cement concrete is, therefore, an unsuitable material for sewers.

Taking all the above considerations in view as well as the availability of second-hand 4″, 5″, 6″, 7″, 8″ C. I. pipes on the railway, these have been used at a rate cheaper than any of the alternatives. Thus surplus railway second-hand stocks were used up after scraping, cleaning and painting inside and out with bitumastic solution.

49. All C. I. pipes used are spigot and socket. The joints have been made with molten lead except in some difficult positions in water-logged ground where lead yarn was used. Molten lead was found preferable for jointing C.I. pipes, being cheaper and more satisfactory than lead yarn. To make the joint, rope yarn is first forced inside up to a depth of one-third of the actual length of the joint. Molten lead is run in through a clay mould made at the face of each joint. On breaking the mould lead is beaten home with a caulking tool inside and flush with the face of the joint.



In water-logged ground pipes have been embedded on a layer of four inch plain cement concrete 1:4:8. A typical section of pipe trench showing strutting and shoring of sides is shown in the sketch.



50. The slope of the sewers in the required directions being too flat (1 in 250 to 1 in 380) to permit self-cleansing gradients, a flushing tank has been provided at the head of the main sewers. The branches have been designed with a flattest slope of 1 in 80 which gives a self-cleansing velocity in a four inch diameter pipe. All sewers have been ventilated by vertical vent pipes fixed on the outer walls of buildings. Where there are no suitable structures in close proximity, separate vent pipes held by wire guys have been installed.

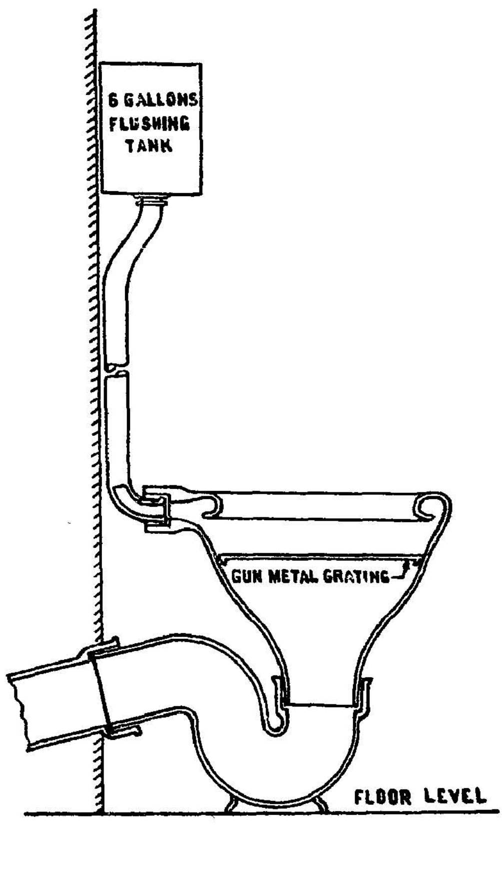
51. The internal sanitary fittings have been roughly divided in three scales, viz., (i) officers', (ii) subordinates, (iii) menials, except for special buildings. Assistant and Divisional Officers are given a long bath and a closet in one room and also a separate closet and bathroom, as well as modern hot water installation on an economic scale.

Subordinates quarters with courtyards have been fitted with two closets (one European and one Indian) to suit the occupants of both nationalities. The menial staff have been provided with group latrines containing Indian type of closets both for males and females. Trough type latrines were found in addition to other disadvantages to be extravagant in water consumption except in units of 8 seats and over. Consequently individual flushing has been used.

For the purpose of determining the number of seats required, an average menials' family has been taken as two adults (one male and one female) with two children taken equivalent to one adult. A latrine seat has been provided for each 20 adults on the above basis.

Where required for disposal of night-soil collected from open latrines and "dry system" closets provided for all semi-permanent quarters and types Q. 27 and Q. 26-A pucca quarters, an additional seat has been installed in the group latrines to provide a dumping pit. (See sketch).

Stone traps are provided at all group latrines. The distance apart of manholes (200') is within the length covered by practicable lengths of rodding, namely, 100' to 110', a very important point in view of gross misuse of the sewer system.



51. For group latrines the maximum number of seats has been taken as 8 (in one case 10). All railway latrines, therefore, are individual flushing, each provided with 3 gallon flushing tanks.

Different types of closets available in the market were thoroughly investigated by the Chief Medical Officer of the Railway, who made the following selections to give maximum service and convenience at minimum cost. Twyfords (English make) fittings were found superior to Indian manufacture at very little difference in cost.

1. For superior bungalows and quarters—

(a) Twyfords Civic .. European type closet (cost Rs. 45 with seat).

(b) ,, Uriclose .. Indian type closet inside Bungalows (cost Rs. 49).

(b[1]) ,, Calcutta .. Indian type closet for latrines located in courtyards of pucca quarters (cost Rs. 20).

2. For menial staff—

(c) Twyfords Orissa for use of females (cost Rs. 50).
,, Uriclose for use of males (cost Rs. 49).

53. **Disposal of sewage.**—The Railway sewers connect up to the Quetta main sewerage disposal works (under the direction of the M. E. S.) a contribution to the capital cost and maintenance of which is made by the Railway. The Railway population served by sewerage scheme is about 2,130 adults and 1,380 children.

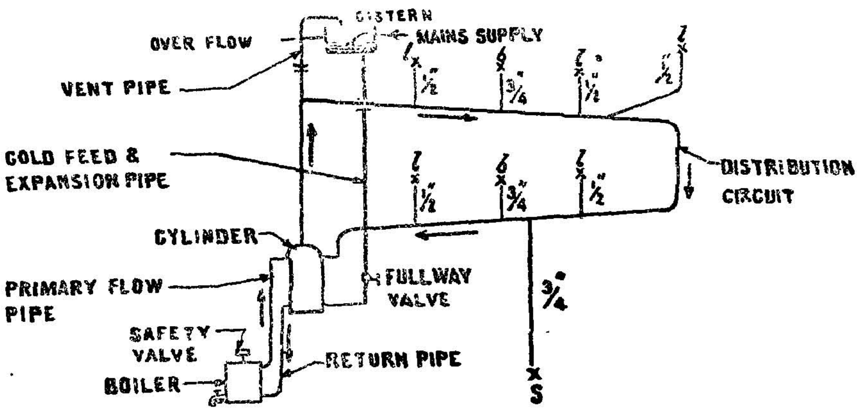
54. Tenders for the railway sanitation works were called from contractors technically qualified for executing this type of work against bills of quantities, specifications and schedule of rates separately for sewers and sanitary installation respectively. On working out the totals in the bills of quantities at the rates tendered by individual contractors the various tenders could be compared. Detailed estimates were then framed at the accepted tendered rates as follows—

	Without contingencies. Rs.	With contingencies. Rs.
(i) Construction of sewers ..	1,92,109	2,01,714
(ii) Internal sanitary fittings ..	1,87,853	1,97,246
(iii) Staff latrines	15,681	16,465

55. **Modern Sanitary Installation at Sibi.**—There is no sewerage scheme in Sibi. The Running Rooms have, however, been equipped with flush system fittings and the sewage is disposed of through septic tanks as shown in Plate No. 14.

Each septic tank is designed for one W. C. and one urinal, which are supposed to serve five users a day at the rate of 15 gallons a head. Providing for 24 hours storage the capacity of the tank is taken at 150 gallons equivalent to $4' \times 1\frac{1}{2}' \times 4'$. Sewage is led through a vertical pipe into the first chamber where it breaks up and a baffle wall divides the tank into two chambers. The effluent collects in the second chamber whence it is led through a system of dry brick drains nearly four feet under ground, 15 feet in length for each user. The installation at Sibi has given no trouble whatever in the first year of working.

56. **Domestic hot water installation.**—Officers bungalows at Quetta are equipped with hot water installation. The apparatus consists of a small boiler, a cylinder for storage of water and a closed circuit distribution system. (see sketch).



The capacity of the cylinders has been calculated on the following basis—

Bath ..	.. 15 gallons each.
Wash-hand basin (private)	.. 3 ,, ,,
,, ,, (public)	.. 10 ,, ,,
Sink ..	.. 10 ,, ,,

On the above basis, the boiler rating on normal-firing is 1,000 B. T. U. per gallon of cylinder capacity. The boilers are designed for a steam pressure of 100 lb. per square inch and the supply of hot water at taps to be at a temperature of 150° F., one hour after each boiler is lit.

The capacity of the cold water storage cistern is more than 50 per cent of the size of the cylinder plus 25 gallons for each W. C. or urinal cistern. The apparatus is manufactured by the Ideal Radiator Co., Hull, England.

CHAPTER IX

Minor Engineering points of interest, economies, plinth areas and costs

57. Major points of engineering interest have been dealt with in previous chapters, but many minor devices have been introduced, mainly as remedies to defects in earlier designs. For example, a frameless courtyard door which is proof against the heaviest battering by wind, flexible verandah posts, fireplaces for quarters and kitchens ranging from officers' bungalows to menials quarters, new types for doors, hollow brick and clay covering insulation for R. C. C. slab roofs of buildings in hot areas (Sibi) and numerous other devices, drawings of some of which are on Plate No. 13. In the case of R. C. C. slab roofs at Sibi, the hollows in the bricks (specially mouled at the rather high rate of Rs. 30 a thousand) act as tunnels to carry away any sun heat which penetrates the five inches thick top layer of mud and mud plaster. To keep out birds and vermin, there is a layer of wire gauze over the open ends. The experiment of closing the ends was tried and showed that circulation through the brick tunnels is preferable. To complete the installation there should be a layer of mud plaster between the hollow bricks and the R. C. C. slab. The surface is finished with three coats of whitewash.

The striving after economy has been continuous. The most important step has been the use of controlled methods of proportioning cement concrete and mortar, which has resulted in a nett saving (after deducting the extra cost of grading and testing aggregates) of about Rs. 25,000 (see Chapter 6). Less scientific, but more remunerative, has been the invention and extensive use of the type of construction called "semi-permanent" (see Chapter 7). Under this head alone the saving compared with the cost of permanent quarters has been about Rs. 2,00,000. Other economies comprise (1) purchase of 70 lacs of salvaged bricks from ruins of Quetta City (representing a saving of about Rs. 49,000), (2) Rs. 1,03,000 by reconditioning and re-use of salvaged railway materials, including roughly 90 lacs of old bricks, about two thousand old doors and windows, and great quantities of old corrugated iron sheets, beams, &c., (3) use of about 700 tons of steel joists sections which had been lying for many years in the Lahore Stores, scrap wagon channels and railway carriage floor sheeting, (as roofing materials) as well as lesser items (such as brick-bats from the ruins used for flooring concrete and soling roads) and careful control of scrap wood and steel for auctioning.

58. In designing the Police barracks for Mastung Road and Chaman, and the billiard room for the European Institute at Quetta, the span was made to suit the roof trusses of the old Quetta Railway station thus enabling about twenty salvaged timber roof trusses to be

re-used intact. The parcel office tonga sheds, and the bullock stables, at Quetta are steel frame buildings designed to utilize scrap and salvaged steel beams and channels. The total value of all these economies is about Rs. 4,00,000, the balance of savings on the project being attributable to the retention of (in place of rebuilding) unshaken workshops, tank stagings, loco. sheds and other buildings near the boundaries of the danger area by strapping them with rails and tie rods, replacing unsafe mud masonry verandahs by framed types, removing excrescences, and converting doors to open outwards. The pin hinge devised for swivel doors (for use where gauze doors are provided as well as ordinary doors) is shown in Plate No. 13.

59. **Plinth and Room Areas.**—In the early days of the project diagrams and tables were received from the Central Committee comparing room areas adopted by various Government Departments and corresponding scales of pay of occupants. From a study of these it was apparent that in the higher paid subordinate categories the North Western Railway standard types were in many cases more capacious than those of other departments. In designing the quarters for Quetta Reconstruction the room areas were reduced to those recommended by the Central Committee, the "Reconstruction" percentages of main room areas compared with North Western Railway types being 71 per cent, 76 per cent, 99 per cent, 80 per cent for types Q.32, Q.30, Q.28, Q.27 respectively. In menials quarters the North Western Railway types were less in area than the Central Committee recommendations. For the cool areas type this defect was overcome by the simple expedient of joining the small kitchen to the main room, an arrangement convenient and economical for occupants, particularly in winter. For hot areas the main room was enlarged by 20 square feet.

At Sibi, (a very hot area indeed) room areas adopted are those standard on the North Western Railway. They are more capacious than the cool area types to the extent of the percentages already given and are also from one foot to two feet higher. Great attention has been paid in Sibi Reconstruction to heat insulation, the only possible compensating economies having been extensive use of salvaged doors, windows, roof timbers, &c. The line diagrams on Plate 11 give at a glance the main room, side room, court yard and plinth, areas of representatives "Reconstruction" types for both cool and hot areas.

Types of officers' bungalows closely follow the recommendations of the Central Committee, including provision of laid-on hot water and (as in the case of all quarters, for staff on pay of Rs. 100 p. m. and above and on Rs. 65 in the hospital area) flush system sanitation

The following table gives the plinth and room areas in comparison with standard North Western Railway types and shows how the overall dimensions have been reduced with small loss in room areas.

	Divisional Officers		Assistant Divisional Officers	
	Quetta Reconstruction	Standard N. W. R.	Quetta Reconstruction	Standard N. W. R.
Plinth area ..	3029	5612	2582	2939
Main rooms ..	1561	1821	1220	1036
Side rooms ..	941	1541	895	770
Verandahs ..	98	1303	28	521

60. **Costs.**—Apart from the figures already given for the probable final cost of the project (Rs. 76,00,000) of particular interest are representative figures of plinth area rates for various types of buildings. Costs comparable with "katcha—pucca" methods of constructions standard in the plains cannot be expected for bricks in cement, concrete reinforced, earthquake resisting, buildings constructed in a relatively remote and undeveloped district such as Baluchistan. The higher figures show the price paid for use of structural frames and expensive methods of construction (including for example new wood for roof lagging, concrete verandah frames, items of work priced high in the schedule of rates, &c., &c.) during the first two years of the project. The lower figures show the effects of economical design and extensive use of salvaged and second-hand material during the latter years of the project.

Cost of Earthquake Resisting Railway Buildings at Quetta.

Type of quarters and description	Average P. A. in S. ft.	Average cost	P.A. rate per S. ft.	Remarks
			Rs. a. p.	
Q. 26 (menials) R. C. C. framed.	203	1114	5 7 6	For R.C.C. framed quarters built during 1936-7.
Q. 27 (Junior subordinates) R. C. C. framed.	599	3628	6 1 0	
Q. 30 (senior subordinates) R. C. C. framed.	1225	6893	5 10 0	
Q. 26 (menials) Semi-permanent.	112	246	2 3 3	Actuals for S.P. quarters built during 1936-7.
Q. 28 (senior subordinates) Semi-permanent.	629	1817	2 14 3	
Q. 26-A (Artisans) Semi-permanent.	406	1281	3 2 6	Actuals for S.P. quarters built during 1937-8.
Q.27 Semi-permanent ..	435	1479	3 6 6	

Type of quarters and description	Average P. A. in S. ft.	Average cost	P.A. rate per S. ft.	Remarks
			Rs. a. p.	
D. O.'s bungalows, R.C.C. framed.	3039	16571	5 7 0	1938-40 program. Actual figures.
A. D. O.'s bungalows (E) R. C. C. framed.	2514	14170	5 10 0	
A. D. O.'s bungalows (N) R. C. C. framed.	2502	14270	5 11 0	
Railway Station R. C. C. framed.	..	..	7 15 0	
D. S. Office R. C. C. framed	..	..	6 5 0	
Kolpur (cool area types)				
Unframed (light banded)—				
Q. 26	182	708	3 14 3	Actuals for quarters built during 1938-9. Q. 28 type quarters new wood has been used in roofs.
Q. 26-A	404	1523	3 12 3	
Q. 28	1127	5089	4 8 3	
Railway Reconstruction Quarters built at Sibi (hot area types) (Light banded with thick walls)—				
Q. 26 sleeper roofs ..	196	878	4 8 0	Actuals for quarters built during 1938-9.
Q. 26-A sleeper roofs ..	441	1925	4 6 0	
Q. 30 slab roofs ..	1899	8715	4 9 6	
Q. 27 sleeper roofs ..	669	3009	4 8 0	
Kishingi (cool area type)				
Q. 26 Semi-permanent ..	191	597	3 2 0	Actuals for S. P. Type Q. 26 (cool area type) with J.M.R. frame built during 1938-9 (tender 5 per cent above).
Spintangi (hot area type with 2″—6″ high masonry in cement sub-wall).				
Q. 26 Semi-permanent ..	186	609	3 4 6	

Note.—Where courtyards exist the costs are added to those of the buildings, but the areas of courtyards or any other uncovered works are not included in plinth areas.

Items such as servants quarters, boundary walls, private roads, electric, modern sanitary and hot water fittings and branch sewers (which are included in rent statements) are not included in the above figures of plinth area rates.

APPENDIX I

QUETTA RECONSTRUCTION

Designs of Earthquake Proof Buildings, General Principles and Rules.

(Requirements shown in small type were subsequently withdrawn).

1. **General.**—(a) Symmetry of plan, elevation and foundation loads are of fundamental importance.

(b) Mass and rigidity should be as nearly uniform as possible.

(c) Excessive length in proportion to width is undesirable. A square or compact rectangular plan is desirable.

(d) Buildings should be as light as engineering considerations and considerations of health and comfort permit.

(e) The centre of gravity should be kept as low as possible.

(f)(i) Adjacent buildings having different natural periods or amplitudes should be separated by a sufficient distance to prevent their hammering one another.

(ii) When connexions such as passages are used they should be flexible.

(iii) When adjacent buildings cannot be sited sufficiently far apart to prevent their hammering one another, they must be rigidly interconnected.

(g) Sites should be, as far as possible, on level, homogeneous and firm ground.

Sites near abrupt changes in the surface level or in the strata should be avoided.

2. **Foundations.**—(a) Foundation pressures are not to exceed 70 per cent of the safe bearing pressure.

(b) Foundations must be solid mats for continuous beams or so strongly tied together that they act as one unit; this includes the footing of columns.

(c) Foundations must be stiff enough to transmit lateral seismic forces in any direction without distortion.

(d) A reinforced concrete beam-and-slab mat poured integrally is an ideal aseismic foundation. Where the soil is not uniform or where the soil yields excessively under pressure such a foundation should be used.

(e) As far as possible foundations should be free to move horizontally on the supporting sub-soil. It is very desirable that the bottom surfaces of all parts of the foundations of one structure should be on the same level. When beam foundations are used the whole foundation area should be excavated.

3. **Superstructure.**—(a) Every room which is to be occupied simultaneously by 10 or more persons and which is 20 feet or more in length or breadth and every dwelling house with a plinth area of 800 square feet or more is to have a structural frame of either steel or reinforced concrete.

(b Frames must be sufficiently rigid to withstand distortion, diagonal or knee bracing must be used where necessary to ensure the necessary rigidity. They must be rigidly interconnected and must be rigidly fixed to the foundations in such a way that the foundations and the frames form one integral unit.

(c) Every building shall have all its parts tied together in such a manner that the structure will react to seismic forces as one unit, the connexions being strong enough to overcome the inertia of the various parts.

APPENDIX I—(Contd.)

(d) Parapet walls, cornices and ornamental details should be avoided as far as possible. If used they must be firmly attached to the structure so as to form an integral part of it. Chimneys should generally be of reinforced concrete or of sheet metal or cement asbestos.

(e) It is desirable that internal partition walls should meet at a common vertical.

(f) Doors and windows should be kept away from corner columns; they should be so arranged as to avoid planes of weakness.

An opening for a door or window will necessitate special reinforcement around it.

(g) At all floor and roof levels horizontal rigidity must be ensured either by partition walls or by beams and diagonal bracing or slabs.

(h)(i) Brick work or unit masonry is to be adequately reinforced horizontally, the reinforcement being firmly fixed to vertical columns or end walls at both ends.

Special care is necessary to ensure that tension stresses in a vertical plane in excess of those for which provision has been made, are avoided.

(ii) (Alternatively) walls of brick or unit masonry shall at all floor and roof levels be adequately tied together longitudinally from outside to outside of the structure by continuous metal rods or other bonds of continuous strength, and shall be tied to all intervening partition walls.

Such rods or bonds shall be embedded in one continuous course adequately fixed to the walls.

(iii) Mortar (in the reinforced joints of reinforced brickwork) is to be of one cement to three sand. (In other joints it may be as weak as 1: 6).

(iv) Doors should open outwards in rooms which may be occupied by 20 persons or more. In such cases the door frame is to be on the outside of the wall. (Single doors should be used wherever possible).

4. **Seismic and wind forces.**—(a) Every building and every portion of a building shall be so designed and constructed as to withstand the bending moment due to a continuously applied horizontal force in any direction equal to at least $12\frac{1}{2}$ per cent of the weight of the building or portion of the building acting where the weight is located.

(b) The horizontal shear at any level of a building to be designed against, shall be not less than $12\frac{1}{2}$ per cent of the total weight of the building above that level.

(c) The weight of a building for the purposes of calculating seismic forces shall be taken as—

(i) The dead weight of the building and all fixtures, together with,

(ii) An allowance for transient live or floor loads equal to one-third of the equivalent dead floor load which the floor is designed to bear, subject (except in the case of store-rooms) to a minimum allowance of 20 lb. to the square foot.

All transient live or floor loads shall be treated as acting at the level of the floor on which they are carried or, when not carried on a floor, at the level of the floor immediately below them.

(d) Wind loads, when less than the loads due to the above horizontal seismic forces, may be neglected.

APPENDIX I—(Concld.)

(e) In the event of these rules being adopted as the basis of bye-laws applicable to the public, it will be necessary to lay down rules *for* use in calculations as regards—

(i) Extent to which tensile and compressive strength of panels may be allowed for in calculating the rigidity of the building in resisting horizontal forces,

(ii) End conditions of beams and columns,

(iii) Assumptions that may be made in respect of a resultant horizontal force equivalent to the horizontal seismic forces as to magnitude and point of application.

5. **Working stresses.**—(a) Working stresses under combined vertical and horizontal forces, including seismic forces, may not exceed those allowed for vertical load alone by more than the following percentages—

(i) In a steel framework	.. ..	50 per cent.
(ii) In a reinforced concrete framework	..	25 per cent.

(b) Working stresses for steel shall be those laid down in British Standard Specification No. 449 of 1932, and all steel, in accordance with clause 2 thereof, shall comply with British Standard Specification No. 15 of 1930.

(c) When special high tensile steel is used, evidence as to its safe working stresses must be forthcoming.

6. **Miscellaneous.**—(a) The difference in cost between a building constructed to resist seismic forces and a normally constructed building increases rapidly with height. In Baluchistan the value of land is so low that it can rarely be economical to build a high building.

(b) In single storey building designed against a seismic factor of four feet per second, the natural period of oscillation is so low that the possibility of an approximation to the period of a dangerous earthquake can be neglected.

(c) There are two aspects of considerable importance from which designs for buildings to resist earthquake must be examined.

These are—

(i) The extent to which heat will be transmitted through the walls and roofs.

(ii) The extent to which special steps are necessary to prevent excessive echo and reverberation.

President.

Members.

APPENDIX II

Design Data adopted by Mr. G. C. Trehan for Earthquake Resisting Buildings on Quetta Division with subsequent modifications.

(a) **Superimposed Load.**—(i) For sloping roofs, a vertical load of 10 lb. per square foot measured on plan and taken as uniformly distributed over the slope of the roof. This includes load on account of snow.

(ii) For flat roofs, a vertical load of 20 to 40 lb. per square foot measured on plan and taken as uniformly distributed.

(iii) For floors, a vertical load of 60 to 100 lb. per square foot of floor area taken as uniformly distributed.

(iv) The following table gives the superimposed equivalent dead loads and wind *load adopted in the later stages of the project.*

	Superimposed load	Wind	Columns
Pitched (sheeted) roofs of slope greater than 20°	Nil (allow 10 lb./S. ft.)	See (b) (ii) ..	Actual loads.
Pitched (sheeted) roofs of slope less than 20°	Nil (allow 10 lb./S. ft.)	See (b)(ii) ..	
Flat roofs and slabs ..	40 lb./S. ft. ..	Nil.	Weight of work plus 25 lb./S. ft.

(b) **Wind loads.**—(i) On vertical exposed surfaces normal to the direction of the wind.

A normal wind force (calculated on the whole area of the exposed surface) of 1 lb. per square foot per foot height of the building. This is not taken in conjunction with seismic forces.

(ii) On inclined exposed surfaces normal to the direction of the wind.

The normal force has been calculated by the Duchemin's formula which gives $P_N = P_H \frac{2 \text{ Sin } A}{1 + \text{Sin}^2 A}$ where P_H = the horizontal pressure=30 lb./ft.^{2} and A=the inclination of the roof to the horizontal. The total wind force calculated in accordance with the above provision has been assumed to act on the windward side only.

(c) **Seismic Forces.**—These have been assumed to be due to a maximum ground acceleration of 4 ft./sec.^{2} or $\frac{1}{8}$ *of acceleration due to gravity*. This force has been assumed to act at the centre of gravity of the mass concerned.

APPENDIX II—(Contd.)

Working Stresses.

A. **Steel.**—As allowed in the L. C. C. Code of Practice.

Reinforced Brickwork—

(i) Bending	in brickwork ..	300 lb./in.²
(ii) Direct	in brickwork ..	250 Do.
(iii) Shear	in brickwork ..	60 Do.
(iv) Bond between steel and brickwork	..	80 Do.
(v) Modular ratio for steel and brickwork	..	40 Do.

Soil—

(i) Under direct loads	.. ..	1·0 tons/ft.²
(ii) Under combined direct and seismic forces		0·7 Do.

Brickwork in 1: 3 (later reduced to 1: 4½ and 1: 5) cement and sand mortar—

(i) Bending (compression)	.. ..	300 lb./in².
(ii) Direct (compression)	.. ..	250 Do.
(iii) Tension (compression)	.. ..	60 Do.

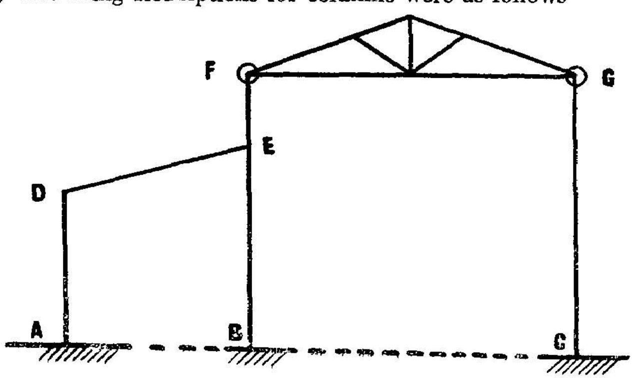
Note.—In accordance with the Central Reconstruction Committee rules it has been assumed that the working stresses (as given above) when considering combined vertical and horizontal forces (including seismic forces) can be exceeded as shown below—

(i) Steel members 50 per cent.
(ii) R. C. members 25 per cent.
(iii) R. B. members 25 per cent.

R. C. Concrete.—1: 2: 4 and leaner mixes according to grading and w/c ratio—

(1) Bending (compression) in concrete	..	750 lb./in.²
(2) Direct (compression)	.. ..	600 Do.
(3) Shear in concrete	.. ..	75 Do.
(4) Bond between steel and concrete	..	100 Do.
(5) Modular ratio for steel and concrete	..	18
(6) Tension in concrete	.. ..	Nil.

(7) The fixing assumptions for columns were as follows—



APPENDIX II—(Concld.)

(i) When A, B, C, are connected by R. C. C. transverse beams at floor level, A, B, C, are fixed 100 per cent

F and G are free (pin jointed).
D and E are rigid, but free to deflect with the columns, with which they form a C. C. frame.

(ii) When A, B, C, are not connected by R. C. C. transverse beams at floor level, A, B, C, are pin jointed.

F, G, are rigid and are rigidly connected by a R. C. C. truss with strong joints at F and G. D, E, are rigid, being part of a C. C. frame.

APPENDIX III

Instructions for Beam Test of Concrete.

The beam 8′ long×3½″ wide×2¾″ deep is placed centrally on two level knife-edges 7′-6″ apart. The details of section and method of loading are shown in sketch on the beam testing sheet attached.

The beam is loaded by means of a yoke, (namely, a D. H. Rail piece, having two notches at the ends 2′-6″ apart, placed over two 1″ diameter steel pieces on the beam) which transmits two single loads equal to 'W' each at a distance of 2′-6″ from either support.

Before applying the load, the width 'b' and height 'h' are measured at the centre of the beam, the point of maximum bending moment, where failure is most likely to occur.

On the centre of the rail is suspended a steel tank, graduated in gallons. The load is applied by gradually filling the tank with water.

After failure the distance 'e' from the bottom of the beam to the bottom of reinforcing ½″ diameter steel bars is measured. The effective depth of the section is given by—

$$d = h - e - \tfrac{1}{4}''$$

The loads carried by the beam at failure are—

1. Weight of R. C. C. beam taken at 160 lb./ft.^{3}
2. External load owing to—
   (a) Weight of 1″ diameter steel pieces+weight of D. H. Rail piece+weight of steel tank.
   (b) Weight of water in the tank.

Stresses due to 1 and 2 are added to give breaking strength. C_b which can be computed from—

$$C_b = \alpha\ W + 175 \text{ in lb./sq. inch.}$$

Where α is a co-efficient obtained by considering the stress-deformation curve as a full parabola which is very nearly the case for ultimate loads for concrete. The table below gives different values of α for various values of 'b' and 'd.'

d=eff. depth of beams in inches	Value of .. α				
	b=width of beam in inches				
	3·3	3·4	3·5	3·6	3·7
1·8	7·44	7·24	7·05	6·90	6·71
1·9	6·70	6·53	6·37	6·21	6·05
2·0	6·09	5·92	5·77	5·63	5·94
2·1	5·55	5·41	5·26	5·13	5·01
2·2	5·08	4·95	4·81	4·70	4·57

Six beams should be cast at a time. Three should be tested after seven and the remaining three after 28 days from the date of casting. Beams should be cast from the actual batches and cured in the ordinary way.

Beams strengths are reduced by 20 per cent to obtain equivalent cube strengths; and cube strengths are reduced by 20 per cent to give equivalent cylinder strengths.

APPENDIX IV

Specification for Aggregates.

(A) **General.**—Aggregates shall consist of natural sands and gravels or crushed stone. They shall be hard, strong, and of non-porous nature, durable and shall be clean and free from all vegetable matter, clay films and other adherent coatings. Weathered stone is prohibited.

(B) **Grading**—

(a) 1½″ *Coarse aggregate.*—It will be of such a size that—

(1) All shall pass through a 1½″ ring in all directions.

(2) 30 to 70 per cent shall be retained on a mesh of ¾″ square measured in the clear.

(3) 70 to 90 per cent shall be retained on a mesh of ⅜″ square measured in the clear.

(4) 100 per cent shall be retained on a sieve having four meshes to the inch.

(5) Its fineness modulus must be between the limits of 7·0 and 7·6.

(b) ¾″ *Coarse aggregate.*—It will be of such a size that—

(1) All shall pass through a ¾″ ring in all directions.

(2) 40 to 70 per cent shall be retained on a mesh of ⅜″ square measured in the clear.

(3) 100 per cent shall be retained on a sieve having four meshes to the inch.

(4) Its fineness modulus must be between the limits of 6·4 and 6·7.

(c) ½″ *Coarse aggregate.*—It shall be of such a size that—

(1) All shall pass through a ½″ ring in all directions.

(2) 10 to 30 per cent shall be retained on a mesh of ⅜″ square measured in the clear.

(3) 30 to 70 per cent shall be retained on a sieve having four meshes to the inch.

(4) 100 per cent shall be retained on a sieve having eight meshes to the inch.

(5) Its fineness modulus must be between the limits of 5·4 and 6·0.

Fine Aggregate.—There will be two sizes of fine aggregates referred to hereafter as Coarse and Fine Sand.

APPENDIX IV—(Concld.)

(d) *Coarse Sand.*—It will be of such a size that—

(1) All shall pass through a mesh of $\frac{3}{16}$" square measured in the clear.

(2) Zero to 15 per cent shall be retained on a sieve having eight meshes to the inch.

(3) 15 to 45 per cent shall be retained on a sieve having 16 meshes to the inch.

(4) 40 to 70 per cent shall be retained on a sieve having 30 meshes to the inch.

(5) 70 to 90 per cent shall be retained on a sieve having 50 meshes to the inch.

(6) 95 to 100 per cent shall be retained on a sieve having 100 meshes to the inch.

(7) Its fineness modulus must be between the limits of 2·2 and 3·2.

(8) The weight removed by decantation should not be more than three per cent.

(e) *Fine Sand.*—It will be of such a size that—

(1) All shall pass through a sieve having eight meshes to the inch.

(2) Zero to 30 per cent shall be retained on a sieve having 16 meshes to the inch.

(3) 20 to 50 per cent shall be reained on a sieve having 30 meshes to the inch.

(4) 45 to 80 per cent shall be retained on a sieve having 50 meshes to the inch.

(5) 95 to 100 per cent shall be retained on a sieve having 100 meshes to the inch.

(6) Its fineness modulus must be between the limits of 1·6 and 2·6.

(7) The weight removed by decantation should not be more than three per cent.

Notes.—(1) Natural gravels or crushed aggregates obtained from hammer type crushers and approved type jaw crusher will be accepted. It has been found that crushed aggregates produced by most ordinary jaw crushers are unsuitable.

(2) Natural fine aggregates complying with the specifications can be obtained in Quetta by screening through a mesh of the size equal to the maximum permissible, but the natural material contains a percentage of excess dirt, which must be removed.

(3) Contractors will be required to submit specimen samples with their tenders. They may also produce samples for test before the date on which tenders will be opened. These samples will be analysed and the Contractor will be informed (on inquiry) whether the material is within the permissible tolerance or not.

APPENDIX V

Instructions for Design of Concrete Mixtures.

Dry rodded weight of sand .. .. .. WS_{DR}
Loosely filled weight of sand .. .. .. WS_L
Dry rodded weight of aggregate .. .. WA_{DR}
Loosely filled weight of aggregate (dry) .. .. WA_L
Bulking percentages .. .. . B_{FS}, B_{CS}, B_2, B_3, B_6

for fine sand, coarse sand, ½" aggregate, ¾" aggregate and 1½" aggregate respectively.

M=fineness modulus required for mixed aggregate=5·7 for 1½" concrete, 5·35 for ¾" concrete, 4·5 for ½" concrete.

M_s=Fineness modulus of the sand.

M_a=Fineness modulus of the aggregate.

r=ratio of volume of sand to sum of volume of sand and aggregate measured separately.

S.F.=Shrinkage factor.

$V(s+a)$=volume of mixed dry rodded sand and aggregate.

V_s=Dry rodded volume of sand.

V_a=Dry rodded volume of aggregate.

G=Total mixing of water in gallons.

V_c=Volume of cement in cubic feet (90 lb.)

V_{RM} =Volume of mixed dry rodded sand and aggregate in cubic feet.

$B=\frac{W_{DR}-W_L}{W_L}\times 100$=Bulking percentage to be obtained separately for sand and aggregate.

Knowing the fineness modulus of both sand and aggregate, the proportions in which to mix them can be calculated as follows—

$$M = r M_s + (1-r)M_a$$

$$= r = \frac{M_a - M}{M_a - M_s}\times 100 = \text{percentage of sand.}$$

Percentage of aggregate=100 − r

Take r parts of dry rodded sand=V_s and mix thoroughly with 100−r parts of dry rodded aggregate=V_a

Resulting volume of mixed dry rodded sand and aggregate=$V(s+a)$

$$S.F. = \frac{V(s+a)}{V_s+V_a}$$

APPENDIX V—(Concld.)

Water.—Quantity is based on minimum cylinder strengths required—

$1\frac{1}{2}''$ unreinforced concrete	900 lb. @ 7 days.	1,350 „ @ 28 „
$\frac{3}{4}''$ reinforced concrete	1,200 lb. @ 7 days.	1,800 „ @ 28 „
$\frac{1}{2}''$ reinforced concrete	1,200 „ @ 7 days.	1,800 „ @ 28 „

G=8 gallons for R. C. C. and 10 gallons for plain concrete.

$G = A.\ K.\ (2V_c + {\cdot}75V_{RM})$.

A=1·0 always for well graduated sand and aggregate.

K=a factor depending on the consistency required.

K=1·0 for $1\frac{1}{2}''$ plain concrete slump up to 2″

=1·1 for $\frac{3}{4}''$ reinforced concrete slump up to 4″

=1·2 for $\frac{1}{2}''$ reinforced concrete slump up to 6″

Thus we obtain V_{RM}

Real Mix.=1: V_{RM}

Dry rodded volume of sand$=\frac{r}{100}\times V_{RM} \div$S.F.=D.R.S.

Dry rodded volume of Agg.$=\frac{100-r}{100}\times V_{RM} \div$S.F.=D.R.A.

Nominal Mix. 1: D.R.S.: D.R.A.

Loose volume of sand=D.R.S. $\times\frac{100+B_s}{100}$=L.S.

Loose volume of sand=D.R.A. $\times\frac{100+B_A}{10}$=L.A.

Field Mix. 1: LS: LA.

From the total amount of water G, must be deducted the water content in the sand and aggregates if these are damp.

All proportions given are per cubic foot 90 lb. of cement. The unit of cement should be 1 bag (110 lb.)

Therefore multiply all quantities of cement, water, sand and aggregate by 11/9.

11/9 C. ft.: 11/9 L. S.: 11/9 LA ..	.. Water 11/9 (G-content).
=1 bag: 11/9 LS: 11/9 LA ..	.. „ „ „
or $\frac{1}{2}$ bag: 11/18 LS: 11/18 LA ..	.. „ 11/18 „

From the volume of fine and coarse aggregate so obtained, the size of boxes shall be determined. Boxes should be one foot square and depth to suit the volume required.

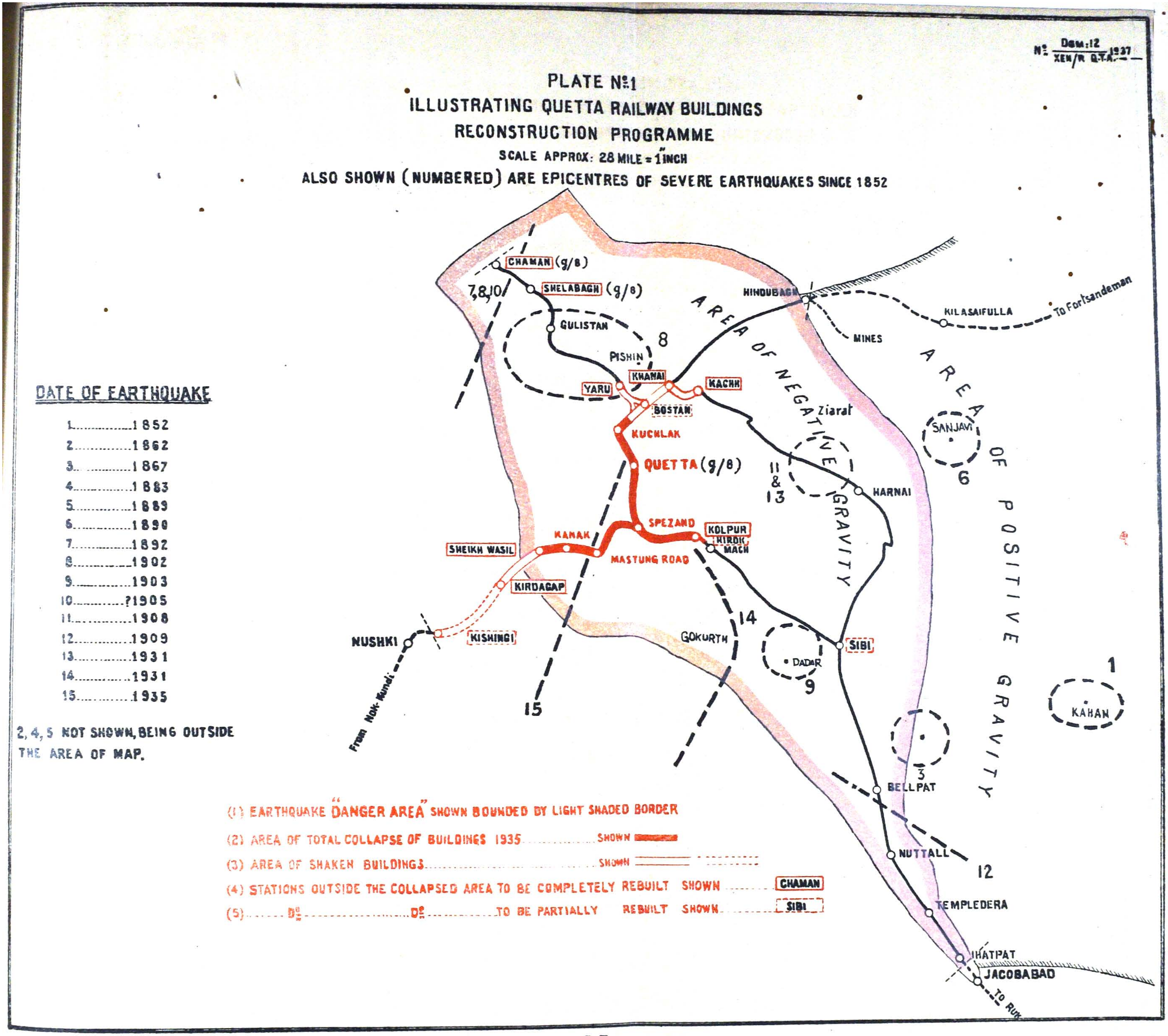
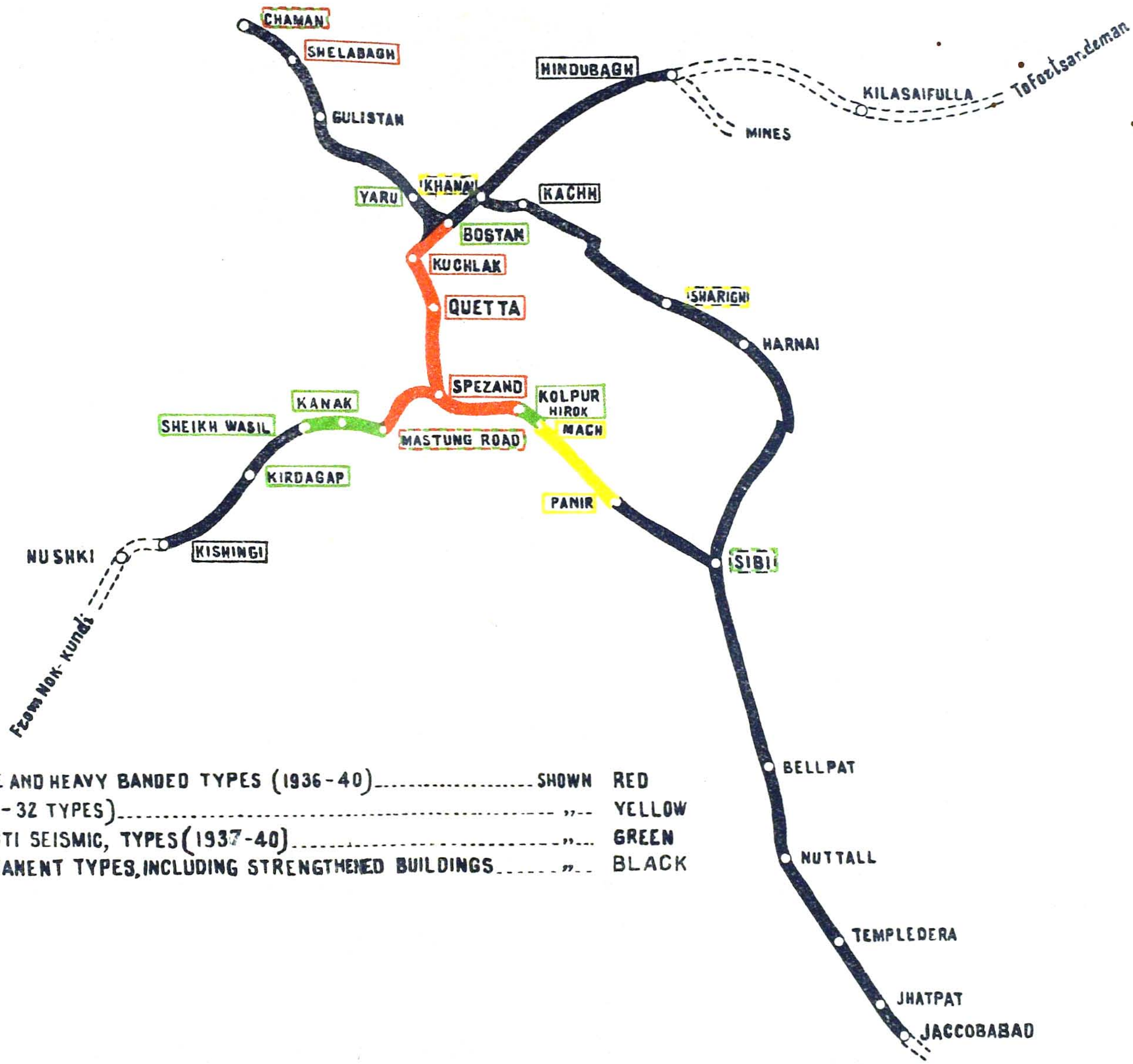

No. Dsm:12 / XEN/R Q.T.A. 1937
PLATE No. 1
ILLUSTRATING QUETTA RAILWAY BUILDINGS
RECONSTRUCTION PROGRAMME
SCALE APPROX: 28 MILE = 1 INCH
ALSO SHOWN (NUMBERED) ARE EPICENTRES OF SEVERE EARTHQUAKES SINCE 1852
DATE OF EARTHQUAKE
1.........1852
2.........1862
3.........1867
4.........1883
5.........1889
6.........1890
7.........1892
8.........1902
9.........1903
10.........?1905
11.........1908
12.........1909
13.........1931
14.........1931
15.........1935
2, 4, 5 NOT SHOWN, BEING OUTSIDE THE AREA OF MAP.
CHAMAN (g/8)
SHELABAGH (g/8)
7,8,10
GULISTAN
PISHIN
8
YARU
KHANAI
KACHH
BOSTAN
KUCHLAK
QUETTA (g/8)
SPEZAND
KOLPUR
HIRDK
MACH
KANAK
SHEIKH WASIL
MASTUNG ROAD
KIRDAGAP
KISHINGI
NUSHKI
From Nok-Kundi
GOKURTH
14
15
HINDUBAGH
KILASAIFULLA
To Fortsandeman
MINES
AREA OF NEGATIVE GRAVITY
Ziarat
11 & 13
HARNAI
SANJAVI
6
AREA OF POSITIVE GRAVITY
DADAR
9
SIBI
1
KAHAN
3
BELLPAT
NUTTALL
12
TEMPLEDERA
JHATPAT
JACOBABAD
TO RUK
(1) EARTHQUAKE "DANGER AREA" SHOWN BOUNDED BY LIGHT SHADED BORDER
(2) AREA OF TOTAL COLLAPSE OF BUILDINGS 1935 .... SHOWN
(3) AREA OF SHAKEN BUILDINGS .... SHOWN
(4) STATIONS OUTSIDE THE COLLAPSED AREA TO BE COMPLETELY REBUILT SHOWN .... CHAMAN
(5) .... Do .... Do .... TO BE PARTIALLY REBUILT SHOWN .... SIBI

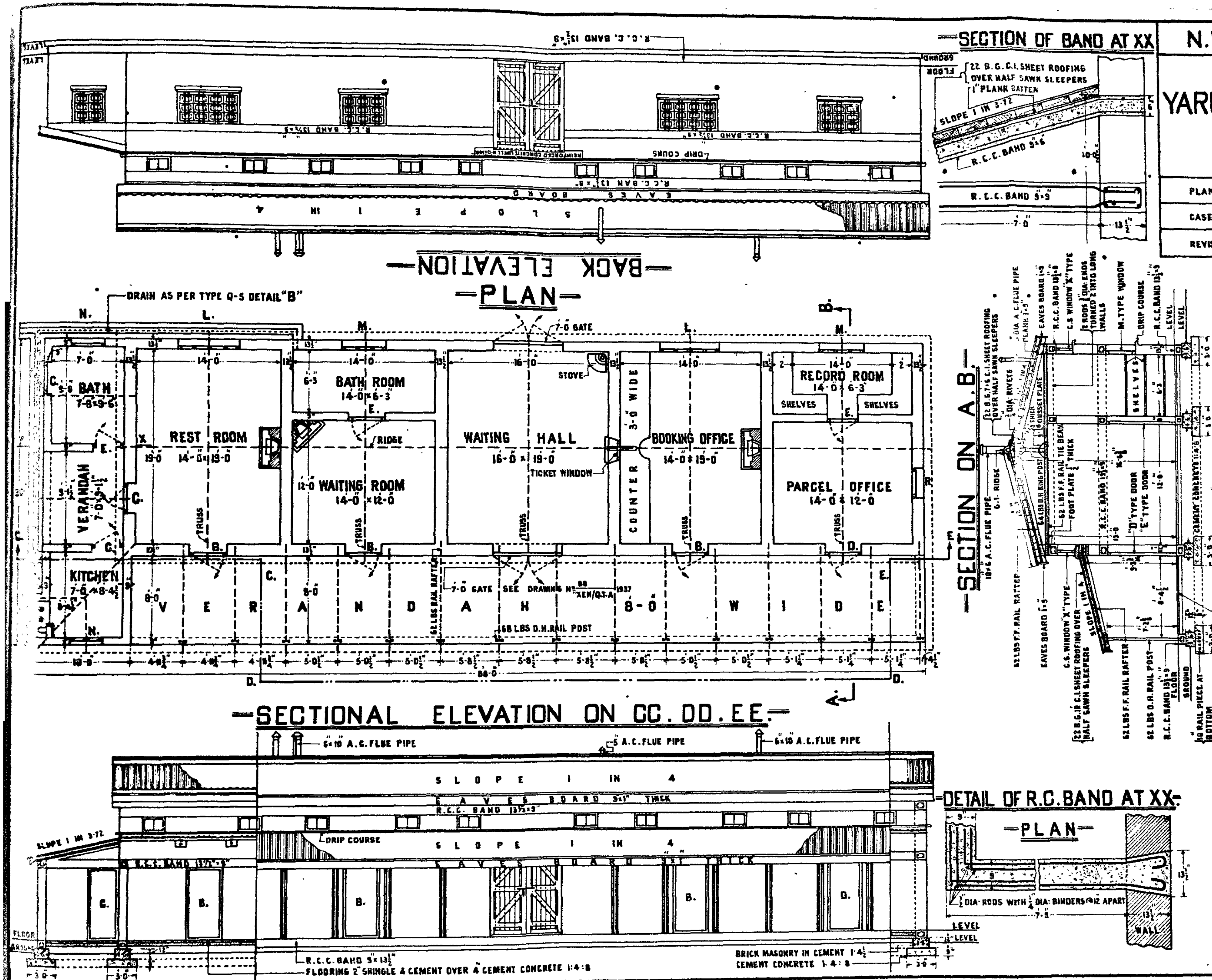
PLATE Nº2

ILLUSTRATING STANDARDS OF EARTHQUAKE PROTECTION TO BUILDINGS OBTAINING ON QUETTA DIVISION ON COMPLETION OF THE 1936-1940 RECONSTRUCTION PROJECT

SCALE APPROX: 28 MILE = 1 INCH



(1) G/8 STRUCTURAL FRAME AND HEAVY BANDED TYPES (1936-40)........ SHOWN RED
(2) G/10 RAIL FRAMED (1931-32 TYPES)........ " YELLOW
(3) LIGHT BANDED, SEMI ANTI SEISMIC, TYPES (1937-40)........ " GREEN
(4) SAFE EXIT & SEMI PERMANENT TYPES, INCLUDING STRENGTHENED BUILDINGS........ " BLACK



N.W.R. "EQ" TYPE Q-29

PLATE No. 3
YARU STATION BUILDING
LIGHT BANDED

PLAN No.

CASE No.

REVISED ON

NOTES:-

1. MAXIMUM PRESSURE ON FOUNDS. 7 TON/□'
2. FOUNDATION TO BE OF CEMENT CONCRETE 1:4:8 & PUCCA BRICK WORK IN CEMENT MORTAR 1:4½.
3. AT PLINTH LEVEL 13½"x9" & 9"x9" R.C.C. BANDS (1:3:6 MIX) TO BE PROVIDED REINFORCED WITH 4 RODS ⅝" DIA: RESPECTIVELY OVER LAPPING 2' AT JUNCTIONS & CORNERS & ¼" DIA ROD BINDERS 12" APART.
4. SUPERSTRUCTURE MASONRY TO BE OF PUCCA BRICK WORK IN CEMENT MORTAR 1:4½ WITH-OUT REINFORCEMENT.
5. AT DOOR & EAVES LEVEL R.C.C. BANDS 13½"x9" TO BE PROVIDED REINFORCED AS IN NOTE 3 ABOVE.
6. REINFORCMENT OF SIDE ROOM R.C.C. BAND AT EAVES LEVEL TO BE AS SHOWN ON THIS DRAWING.
7. FLOORING THROUGHOUT IS TO BE 2" SHINGLE & CEMENT OVER 4" CEMENT CONCRETE 1:4:8.
8. ROOFING TO BE OF 22 B.W.G. C.I. SHEETS AS SHOWN ON THIS DRG.
9. INTERIOR WALLS OF ALL ROOMS EXCEPT FIRE PLACE TO BE CEMENT PLASTERED (1:5) & WHITE WASHED
10. ALL EXTERNAL WALL JOINTS TO BE STRUCK FLUSH WHILE MASONRY PROGRESSES.
11. UNDER SIDE OF HALF SAWN SLEEPERS TO BE PAINTED WITH 3 COATS OF OIL PAINT OF WHITE COLOUR.
12. ALL DOORS TO OPEN OUT WARDS, & TO BE FIXED FLUSH TO THE WALL OUT SIDE.
13. ALL DOORS TO HAVE BOTTOM SILLS.
14. ALL DOORS & WINDOWS AS PER TYPE DRG No. Q 34E & Q-35E.
15. DEPTH OF FOUNDS & HEIGHT OF PLINTH TO BE DETERMINED ON THE SPOT.
16. FROGS OF BRICKS SHALL BE LAID UP-WARDS.
17. FOR DETAILS OF:-

	DWG. No.	N.Q.E. No.
a ROOF TRUSS	121/XEN/Q.T.A 1938	15352/2
b VERANDAH RAIL POST AND RAIL RAFTER CONNECTION	SHEET No. 2 Q.E.D./122	15668
c MAIN ROOM FIRE PLACE	147/XEN/Q.T.A 1938	15766
d SPECIAL WINDOWS	Q.E.D/348	14911/1
e TICKET WINDOWS	97/XEN/Q.T.A 1937	15352/3
f COUNTER	90/XEN/Q.T.A 1937	15352/4
g FLASHING AT JUNCTION OF FLUE PIPES WITH C.I. SHEET	152/XEN/Q.T.A 1938	16732
h ANCHORAGE OF VERANDAH RAFTR TO MAIN WALL AS SHOWN ON THIS DRG		
i KITCHEN FIRE PLACE	Q.E.D/KEPA	15809

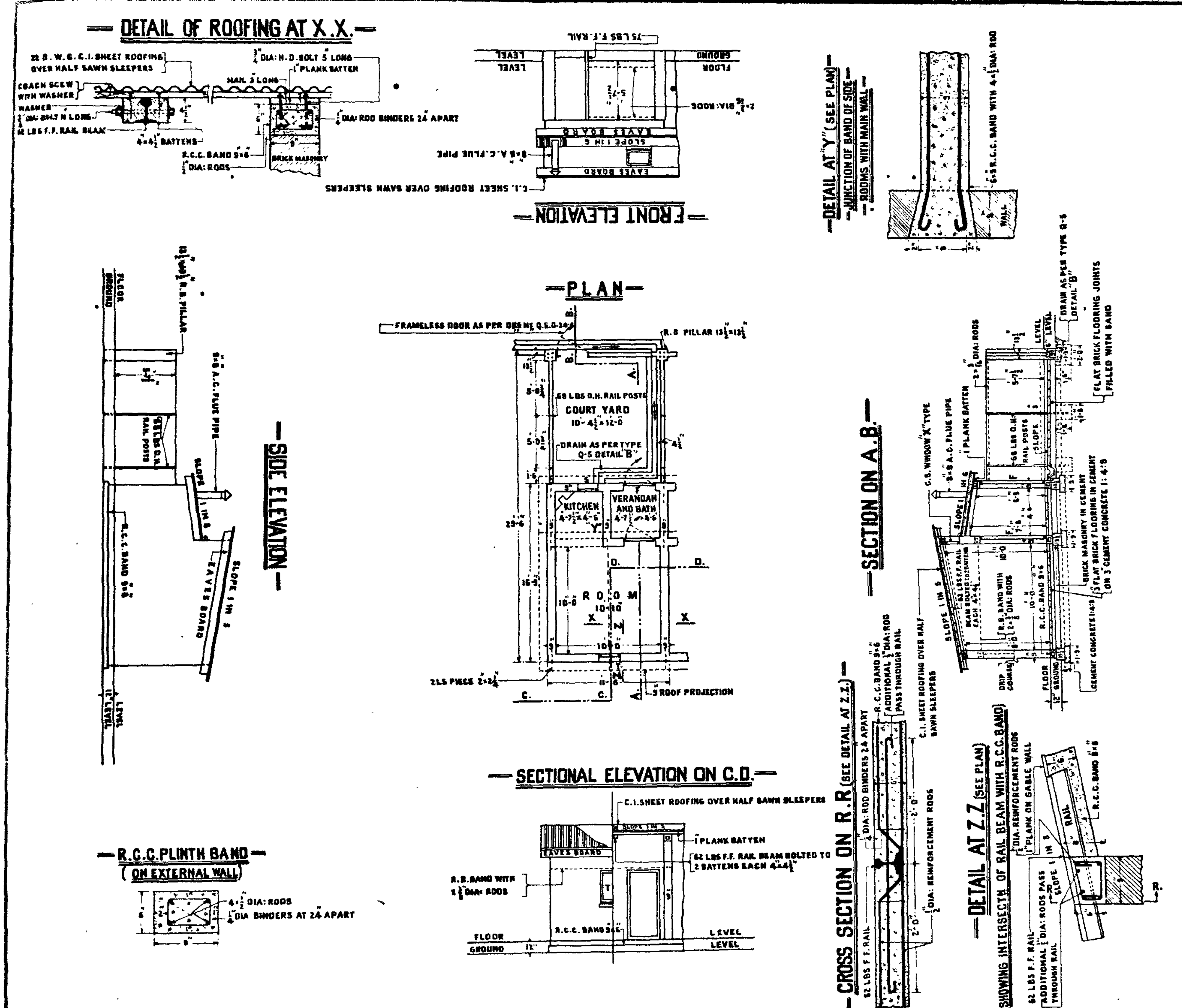


PLATE Nº 4

N.W.R "EQ" TYPE Q-26 (GHAT)

QUARTERS IN COOL AREAS FOR MENIALS & GANGMEN MAXIMUM 9 UNITS

NOTES:-

1 PRESSURE ON FOUNDS 0·7 TON/□'.
2 FOUNDATION TO BE OF ORDINARY 6" CEMENT CONCRETE 1:4:8 NOMINAL MIX: & BRICK WORK IN CEMENT MORTAR 1:4½.
3 AT PLINTH LEVEL 9"×6" R.C.C.BAND 1:3:6 MIX: TO BE PROVIDED, REINFORCED WITH 4 RODS OF ½" DIA: & ¼" DIA: BINDERS 24" APART.
4 SUPERSTRUCTURE TO BE PUCCA BRICK WORK IN CEMENT MORTAR 1:4½ WITHOUT REINFORCEMENT.
5 AT EAVES LEVEL 9"×6" R.C.C.BAND TO BE PROVIDED, AS IN NOTE 3 ABOVE.
6 INTERNAL & EXTERNAL WALL JOINTS TO BE STRUCK FLUSH AS WORK PROGRESSES.
7 FLOOR IN MAIN ROOM, KITCHEN VERANDAH TO BE 3" FLAT BRICK ON 3" CEMENT CONCRETE 1:4:8.
8 ROOFING TO BE OF C.I SHEET OVER HALF SAWN SLEEPERS SUPPORTED BY 62 LBS F.F RAIL BEAM.
9 UNDER SIDE OF HALF SLEEPERS IN ALL ROOMS & VERANDAHS SHOULD BE WHITEWASHED 3 COATS.
10 DEPTH OF FOUNDS & HEIGHT OF PLINTH TO BE DETERMIND BY THE DIVISIONAL ENGINEER ON THE SPOT.
11 ALL DOORS TO OPEN OUTWARDS.
12 ALL DOORS & WINDOWS TO BE TYPE Q-34 E & Q-35 E.
13 ALL DOORS TO HAVE BOTTOM SILL.
14 FROGS OF BRICKS SHALL BE LAID UPWARDS.
15 MIXES GIVEN FOR MORTAR & CONCRETE ARE NOMINAL.
16 FOR DETAILS OF

	DIV: Nº	H.E.Q. Nº
a KITCHEN FIRE PLACE	QED/K.F.P3	15810
b COURT YARD WALL & DOOR	QED/34/4	15865

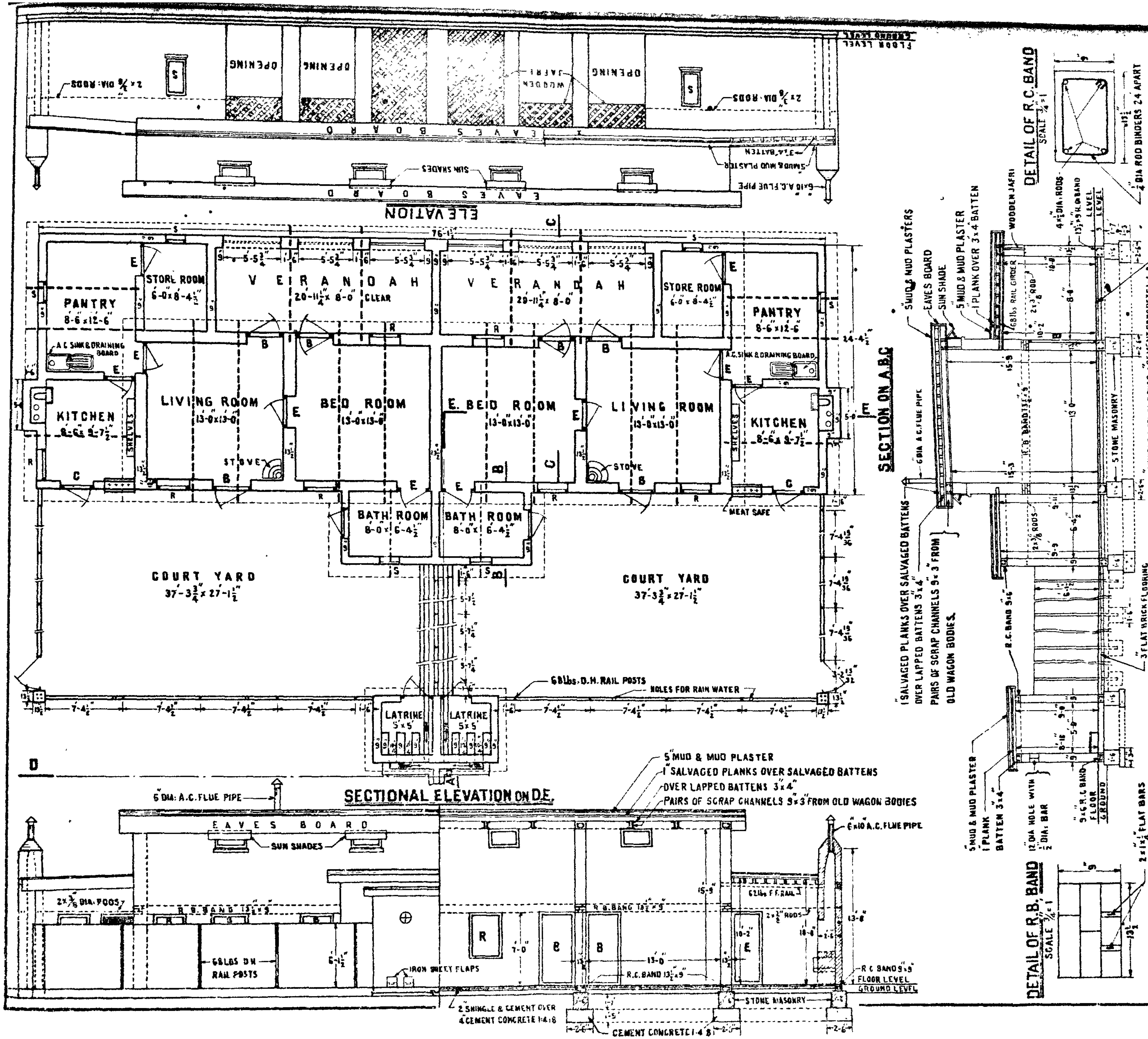


PLATE Nº 3

N. W. R "EQ" TYPE

LIGHT BANDED TYPE OF QUARTERS AT SIBI (Q-28)

NOTE –

(1) MAXIMUM PRESSURE ON FOUNDS 0·6 TON/□'.
(2) FOUNDATION TO BE OF 15" CEMENT CONCRETE 1·4·8 AND PUCCA BRICK IN CEMENT MORTAR 1. 4½
(3) AT PLINTH LEVEL 13½"x9" R C BAND 1 3 6 MIX: TO BE PROVIDED, REINFORCED WITH 4 RODS ½" DIA OVER LAPPING 2 FT AT JUNCTIONS AND CORNERS, AND ¼" DIA: ROD BINDERS 24" APART.
(4) SUPERSTRUCTURE MASONRY TO BE OF PUCCA BRICK IN CEMENT MORTAR 1 4½ WITHOUT REINFORCEMENT.
(5) AT DOOR LEVEL R.B. BAND 13½"x9" TO BE PROVIDED, REINFORCED WITH 2 FLAT BARS 1"x¼".
(6) AT EAVES LEVEL R.C. BAND 13½"x9" TO BE PROVIDED, REINFORCED AS IN NOTE 3 ABOVE.
(7) FLOORING THROUGHOUT 2" SHINGLE AND CEMENT OVER 4" CEMENT CONCRETE 1 4·8
(8) ROOFING TO BE OF 2 CHANNELS 9"x3" UNDER 3"x4" BATTENS.
(9) INTERNAL WALLS OF ALL ROOMS TO BE CEMENT PLASTERED (1:5) AND WHITE WASHED.
(10) ALL DOORS TO OPEN OUTWARDS
(11) ALL DOORS TO HAVE BOTTOM SILLS EXCEPT KITCHEN, BATH AND LATRINE DOORS. COURT YARD DOORS.
(12) ALL DOORS AND WINDOWS TO BE TYPE Q-34E & Q-35E.
(13) FROGS OF BRICKS SHALL BE LAID UPWARDS.
(14) DEPTH OF FOUNDS AND HEIGHT OF PLINTH TO BE DETERMINED BY THE DIVISIONAL ENGINEER ON THE SPOT
(15) FOR DETAILS OF –

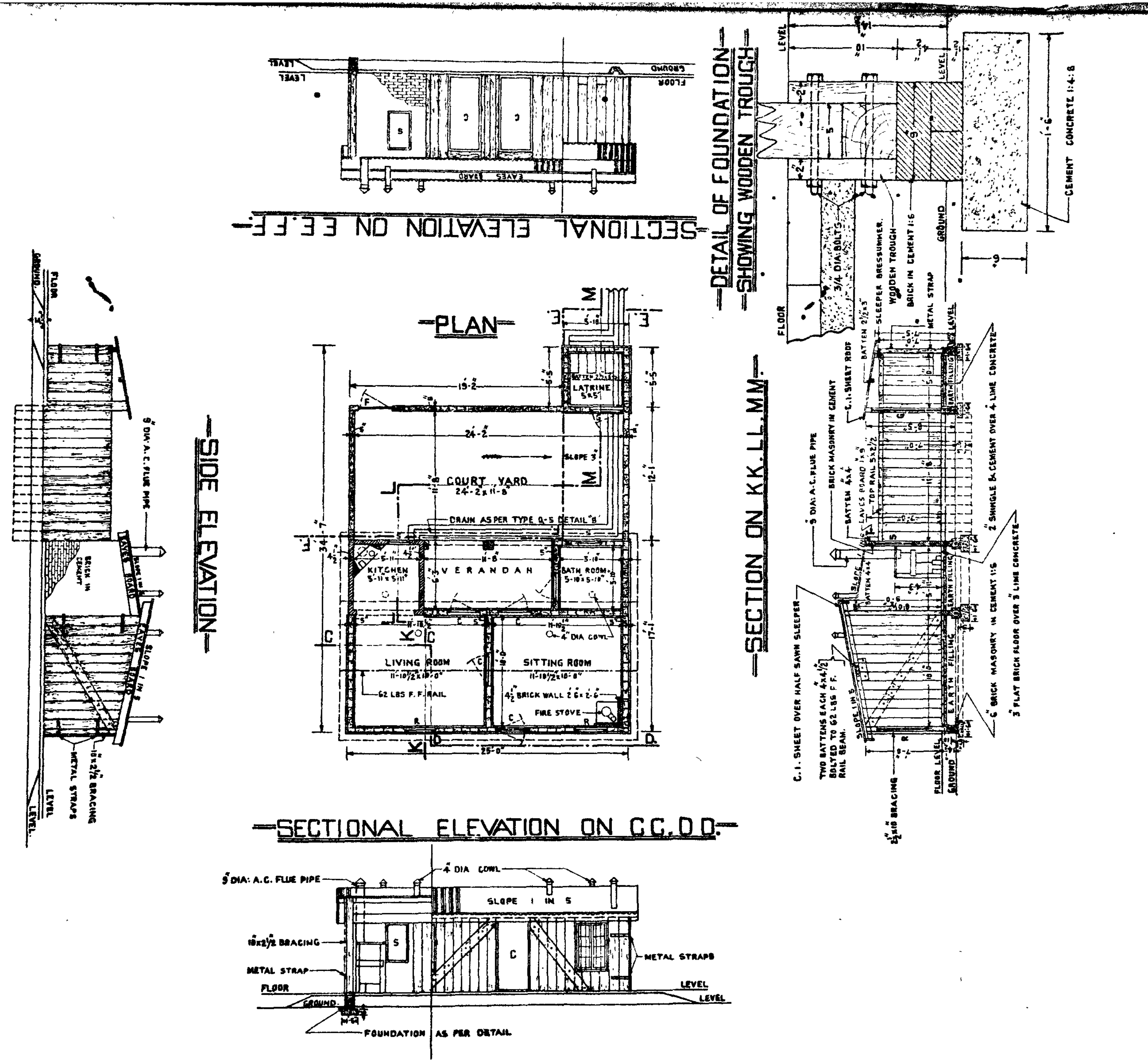
	DIV Nº	HQE Nº
(i) ROOFING AS SHOWN ON THIS DRAWING		
(ii) KITCHEN FIRE PLACE .... SEE DRAWING	Nº QED/KFP4	15889
(iii) A.C. SINK & DRAINING BOARD ...... " ...... "	Nº QED/SDB	15791
(iv) MEAT SAFE ...... " ...... "	————	Q-3
(v) COURT YARD WALL AND FRAMELESS DOOR.	Nº QED/34/4	15810

(16) VERANDAH WITH EAST OR WEST ASPECTS WILL BE PROVIDED WITH TRELLIS WORK.
(17) 2x ⅜" DIA RODS TO RUN AS CONTINUOUS BAND ON ALL WALLS OF SIDE ROOMS AT DOOR LEVEL AND TO TURN 2 FT INTO THE R.B BAND OF MAIN WALLS AT JUNCTIONS.
(18) ALL EXTERNAL WALL JOINTS TO BE STRUCK FLUSH WHILE MASONRY PROGRESSES.
(19) ONE UNIT SERVANT QUARTERS "EQ" TYPE Q-26 PUTT. N.W.R HQE. PLAN Nº 15137/R1 TO BE PROVIDED, WITH EACH UNIT OF THIS TYPE.
(20) MIXES GIVEN FOR MORTAR & CONCRETE ARE NOMINAL.
(21) MUD COVERING OF ROOFS TO BE RAMMED (PHASKA).

PLATE No. 6

N.W.R "EQ" TYPE 27 (GHAT)

SEMI - PERMANENT JUNIOR SUBORDINATE QUARTERS IN COOL AREAS.

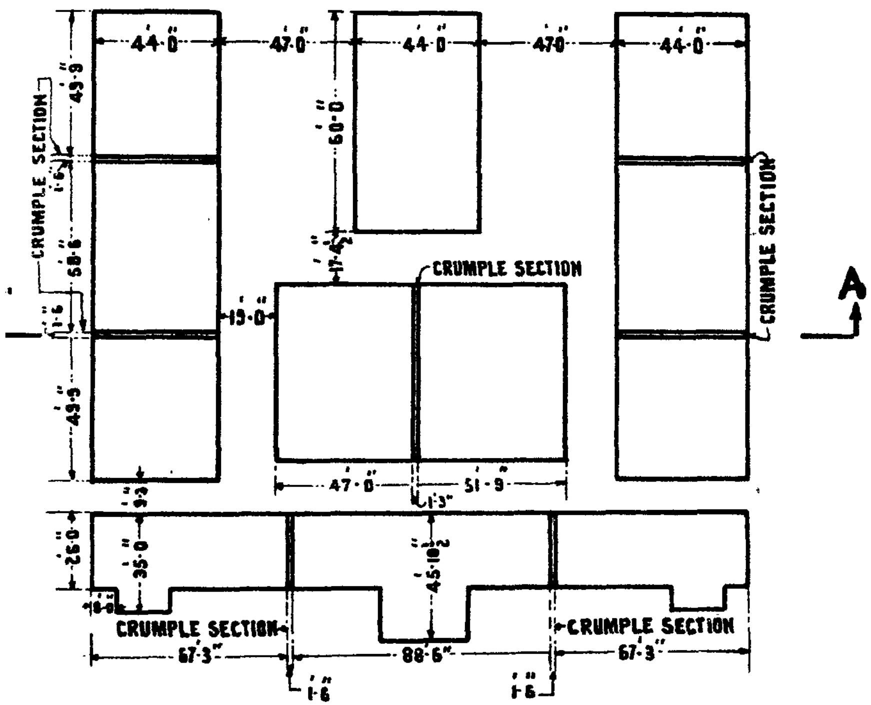


NOTES:—

1. WALLS OF FULL SLEEPERS WITH ENDS SAWN SQUARE.
2. COURT YARD WALLS OF SECOND HAND C.I. SHEETS ON TIMBER FRAME, OR OF U.S. SLEEPERS WHICH EVER AVAILABLE.
3. ALL WOOD WORK TOUCHING THE GROUND TO BE DIPPED IN TAR.
4. FLOOR OF FLAT BRICKS OVER 3" LIME CONCRETE.
5. INTERIOR TO BE MUD PLASTERED AND WHITE WASHED.
6. ALL DOORS TO OPEN OUTWARDS.
7. WALLS OF KITCHEN TO BE PUCCA BRICK IN CEMENT MORTAR 1:6
8. JOINTS OF SLEEPERS (HALF LAPPED OR PLAIN) TO BE CAULKED WITH HOT MIXTURE OF SAND AND BITUMEN.
9. RAIL WILL BE DRILLED THROUGH THE WEB AT 4 FT INTERVALS AND BATTENS TO BE BOLTED EACH SIDE TO FROM AN ATTACHMENT FOR THE ROOF.
10. ROOF TO BE NEW C.I. SHEETS 22 B.G. OVER HALF SAWN SLEEPERS
11. CORNERS TO BE STRENGTHENED BY METAL STRAPS.

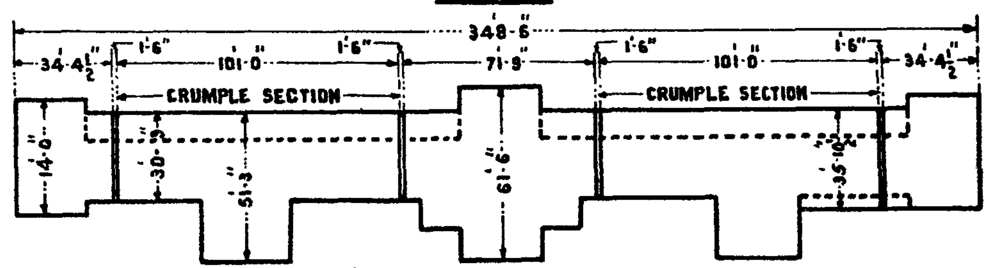
PLATE No. 7
DIAGRAM SHOWING CRUMPLE SECTIONS

DIVISIONAL OFFICE
PLAN



SECTION ON A.A.

STATION BUILDING
PLAN



ELEVATION

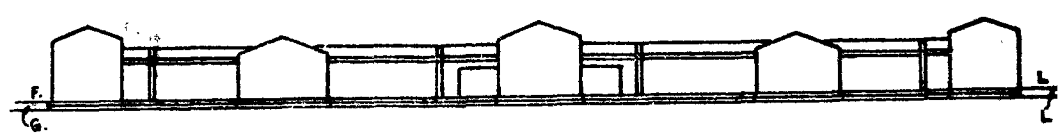
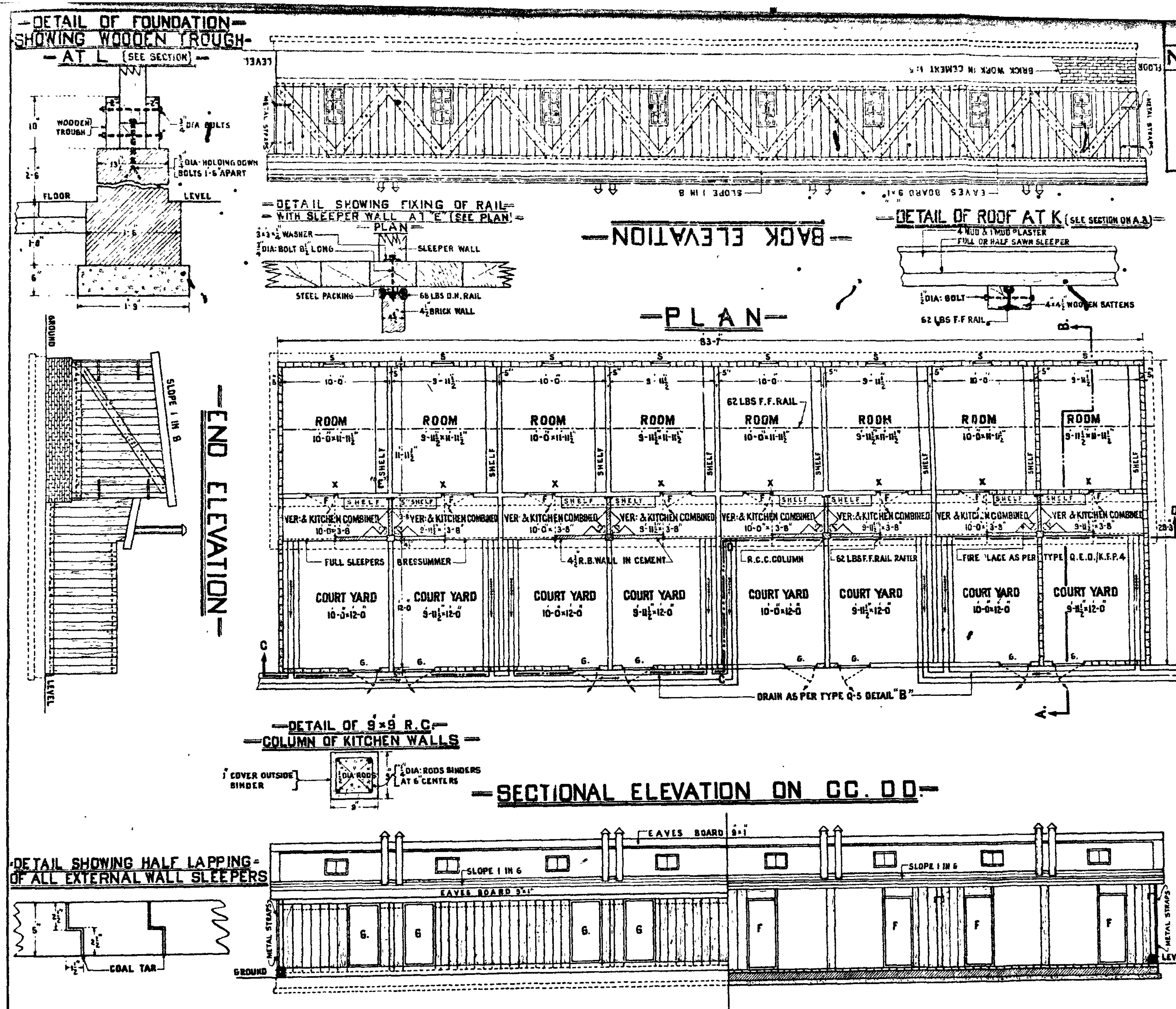


PLATE. № 8

N.W.R. "EQ" TYPE Q-26 (PUTT)

SEMI-PERMANENT MENIALS QUARTERS WITH RAISED PLINTH FOR USE IN HOT AREAS



NOTES:-

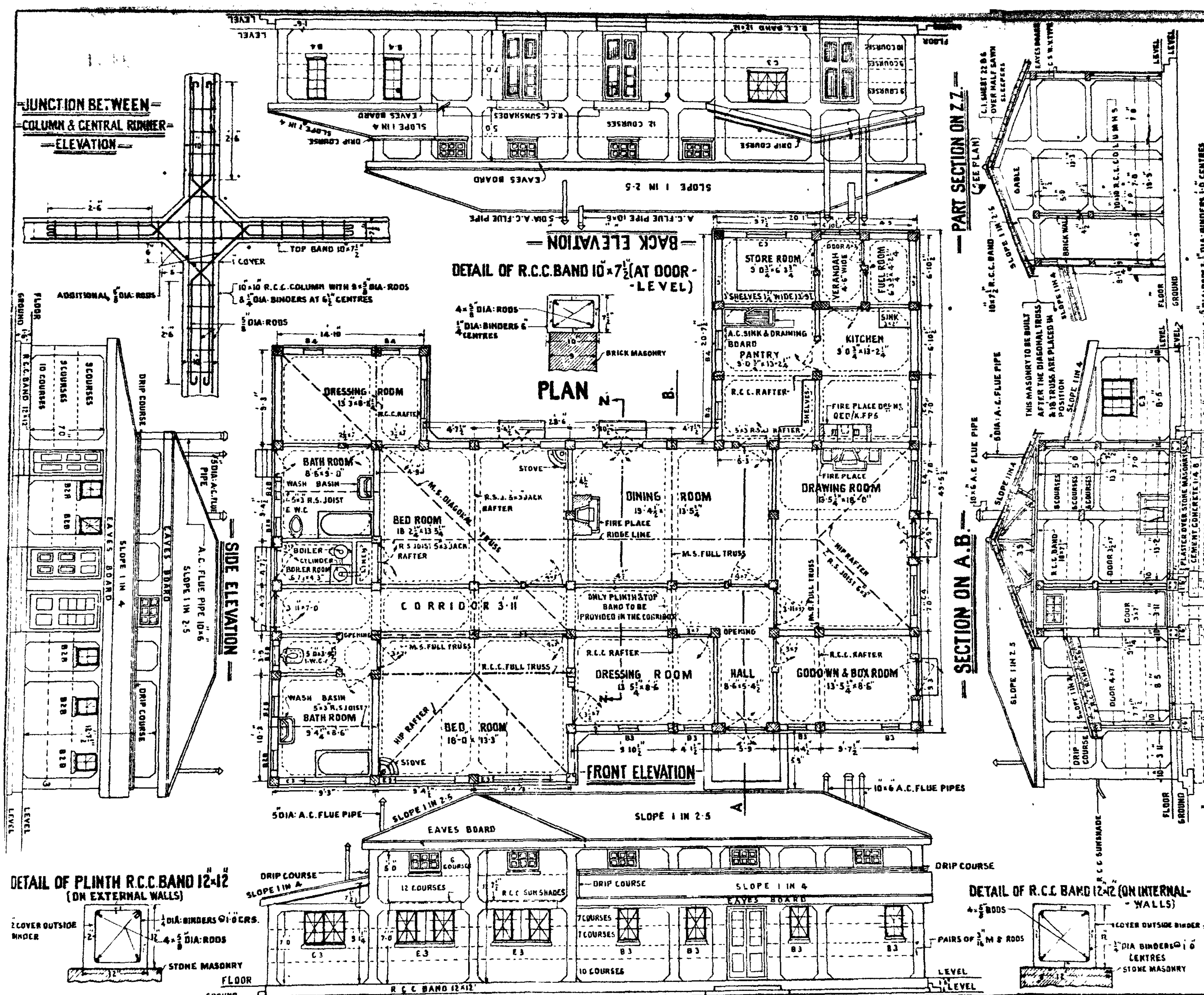
1. WALLS OF FULL SLEEPERS WITH ENDS SAWN SQUARE.
2. COURT YARD WALL..........D°.......D°.......D°.....
3. ALL WOOD WORK TOUCHING THE GROUND TO BE DIPPED IN TAR AFTER CUTTING.
4. FLOOR IN ROOMS TO BE OF FALT BRICKS OVER WEAK CONCRETE AND IN COURT YARD FALT BRICKS LAID DRY.
5. INTERIOR TO BE MUD PLASTERED & WHITE WASHED.
6. ALL DOORS TO OPEN OUTWARDS.
7. FOUDATION TO BE OF ORDINARY 6" CEMENT CONCRETE 1:4:8 NOMINAL MIX & BRICK WORK IN CEMENT MORTAR 1:5.
8. DWARF WALL 2'-6" HIGH TO BE OF PUCCA BRICK IN CEMENT MORTAR 1:5 WITHOUT REINFORCEMENT.
9. MASONRY IN KITCHEN WALLS TO BE REINFORCED EVERY 6TH COURSE.

PLATE No 8

N.W.R. "E Q" TYPE

ASSISTT DIVISIONAL OFFICERS BUNGALOW AT QUETTA

EAST OR WEST ENTRANCE



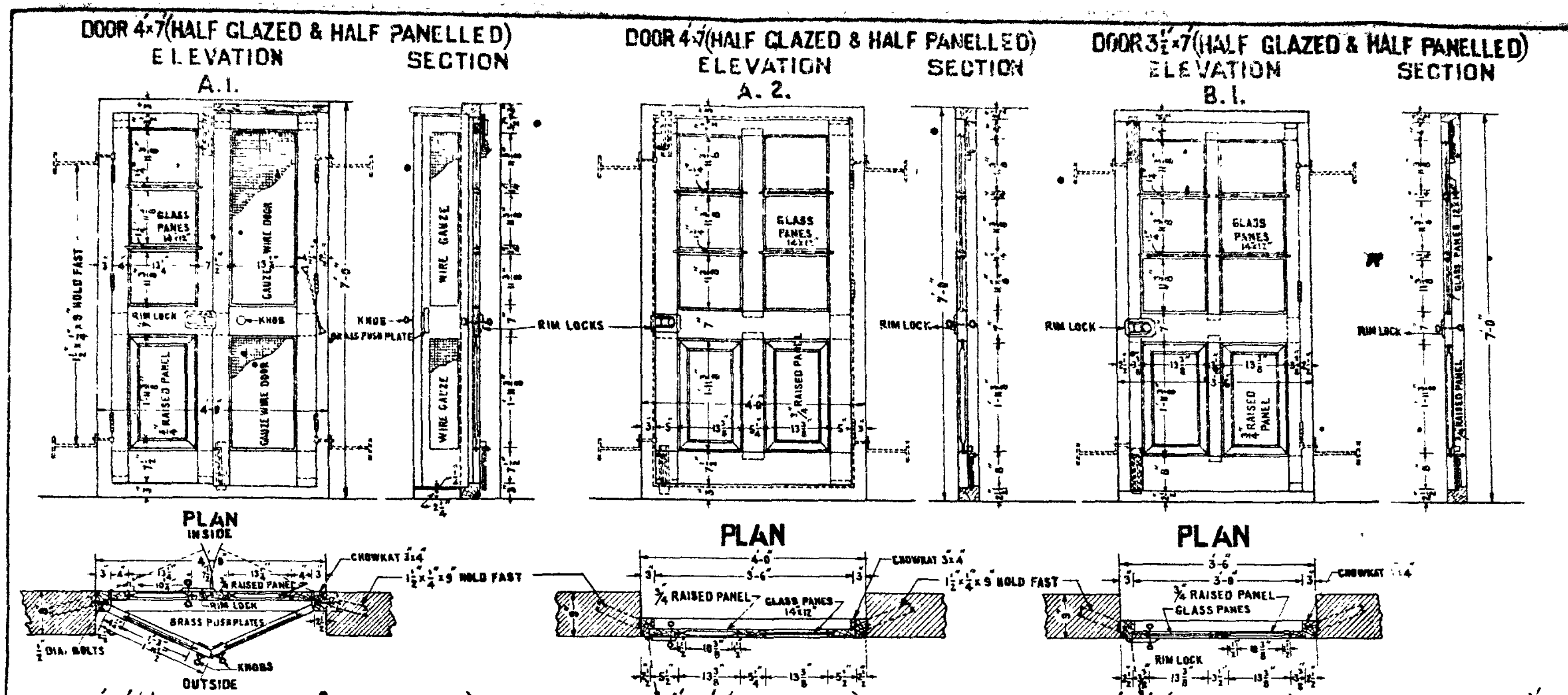
NOTES:-

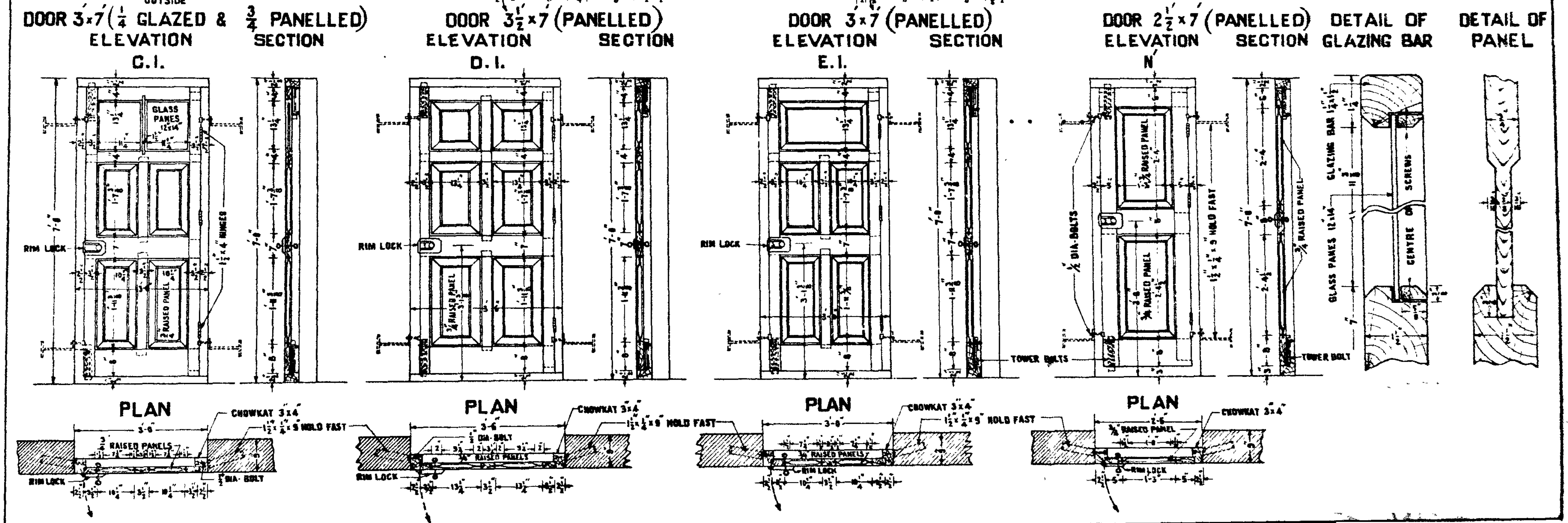
1. MAXIMUM PRESSURE ON FOUNDS 0·6 TON/□'
2. CONCRETE IN FOUNDS TO BE 1½" PLAIN CEMENT CONCRETE WITH A CYLINDER STRENGTH OF 300 LBS PER SQUARE INCH AT 7 DAYS. SLUMP UP TO 2"
3. FONDATION MASONRY TO BE OF STONE IN CEMENT MORTAR 1-5
4. ALL R.C. BANDS, BRESSUMMERS AND RAFTERS OF WHICH THE THICKNESS IS 6" AND OVER TO BE ¾" CEMENT CONCRETE WITH A CYLINDER STRENGTH OF 1200 LBS AT 7 DAYS. SLUMP 2 TO 4 INCHES.
5. ALL R.C.C. COLUMNS AND OTHER MEMBERS OF WHICH THE THICKNESS IS UNDER 6" TO BE ½" CEMENT CONCRETE WITH A CYLINDER STRENGTH OF 1200 LBS AT 7 DAYS SLUMP 4 TO 6 INCHES
6. ALL MASONRY TO BE FIRST CLASS BRICK IN CEMENT MORTAR PANELS TO BE REINFORCED WITH 2×3/16" DIA. RODS IN ACCORDANCE WITH THE DRAWING, FROGS OF BRICKS TO BE LAID UPWARDS.
7. EXCEPT OUTER AND VERANDAH WALLS AND THE WALLS OF BOILER ROOM, STORE ROOM, AND FIRE PLACES, INSIDE SURFACES OF ALL WALLS WILL BE PLASTERED WITH ½" THICK 1 6 CEMENT PLASTER. OUTER & VERANDAH WALLS WILL HAVE THEIR JOINTS NEATLY STRUCK DURING LAYING OF BRICKS.
8. ALL CORNERS AND ANGLES INSIDE ALL ROOMS AND THE EXPOSED CORNERS OF COLUMNS INCLUDING THE ANGLES BETWEEN WALLS AND FLOORS SHOULD BE ROUNDED OFF WITH A RADIUS OF 1½".
9. CEMENT MORTAR WILL BE MIXED IN THE PROPORTION OF 1 5 FOR PLAIN BRICK WORK PROVIDED THE SAND USED IS MEDIUM OR COURSE & THE TENSILE STRESSES ARE NOT LIKELY TO EXCEED 1·75 TON/□' AND 1-3½ FOR ALL REINFORCED COURSES.
10. GAUZE WIRE WILL BE PROVIDED, AS SHOWN IN THE SCHEDULE OF DOOR AND WINDOWS.
11. ALL FLOORS WILL BE OF 2" SHINGLE AND CEMENT VIDE SPECIFICATION 23 B. N.W.R WORKS HAND BOOK, LAID OVER 4" LIME CONCRETE THE FLOORS OF MAIN ROOMS, PASSAGES, DRESSING ROOMS, & THE BATH ROOMS ARE REQUIRED TO TAKE A HIGH POLISH & THOSE OF DRAWING AND DINING ROOMS WILL BE COLOURED.
12. WINDOW PANES OF ALL WINDOWS IN LAVATORIES TO HAVE OBSCURE GLASSES.
13. PAINTS FOR:-
    - (a) STEEL WORK OF TRUSSES... OLPHERTS RED OXIDE.
    - (b) WOODEN DOORS: VARNISHED OVER A STAINING COAT OF TEAK WOOD COLOUR.
    - (c) EAVES BOARD .... GREY
    - (d) STEELITE WINDOWS .... GREY
14. FOR DETAILS OF:- FOUNDATION, 18'-1" SPAN TRUSS, DIAGONAL TRUSS, CP CONNECTION, FIRE PLACES IN KITCHEN & IN MAIN ROOMS, CEILING, SCHEDULE OF DOORS & WINDOWS, LEAD FLASHING, LAVATORIES & STORAGE TANK, R.C.C. COLUMNS, RAFTERS, AND TOP BAND IN SIDE ROOM SEE SEPARATE DRAWINGS.
15. ALL MAIN & LIVING ROOMS & PASSAGE WILL BE PROVIDED, WITH FIBRE CEILINGS.
16. FOR METHOD OF EMBEDDING OF RODS AT JUNCTIONS OF R.C.C. MEMBERS SEE H.Q.E. SKETCH No 030
17. STEEL WINDOWS WILL BE SECURELY FIXED ON ALL FOUR SIDES TO BRICK MASONRY OR R.C.C. BAND OR COLUMN WITH 3" LONG WOOD SCREWS & RAWL PLUGS AT SPACING AS PER SPECIFICATIONS FOR STEEL WINDOWS
18. ALL WOODEN DOORS WILL BE FIXED TO R.C.C. BANDS WITH 2×½" DIA BOLTS & TO MASONRY ON SIDES, WITH ORDINARY HOLD FASTS
19. R.C.C. TRUSS IS MARKED X X. ALL OTHER TRUSSES WILL BE OF MILD STEEL.

PLATE No. 10

N. W. R. "EQ" TYPE

DOORS FOR STAFF QUARTERS QUET,TA RECONSTRUCTION





NOTES:-

1. WOODEN KNOBS & HORIZANTAL BOLTS MAY BE PERMITTED IN PLACE OF RIM LOCKS IN UNIMPORTANT DOORS IF SO ORDERED IN WRITING.
2. WHERE PERMITTED IN WRITING, THE FOLLOWING ALTERNATIVE LOCKS MAY BE PROVIDED.
   (I) FOR INNER DOORS SPRING CATCH TYPE RIM LOCKS NOT EQUIPPED WITH LOCKS & KEYS.
   (II) HORIZONTAL ("ALDROP") BOLTS ON OUTER, STORE ROOM ETC DOORS WITH SIMPLE SPRING CATCH RIM LOCKS OR WOODEN OR BRASS KNOBS. WHERE HORIZONTAL BOLTS ARE FITTED TO DOUBLE DOORS THERE MUST BE TOWER BOLTS TOP & BOTTOM ON THE HALF DOOR WHICH CARRIES THE SOCKET.
   (III) CHAIN & HASP IN PLACE OF ALDROP BOLTS MENTIONED IN (II) ABOVE.
3. DOOR FRAMES SHOULD BE PLACED IN WALLS IN SUCH A WAY AS TO PERMIT DOORS TO BE FLAT AGAINST WALLS WHEN OPEN.
4. IN EARTHQUAKE AREAS OUTSIDE DOORS SHOULD BE OUTWARD OPENING. PIN TYPE HINGES MAY BE USED FOR SWING DOORS.
5. IN PLACE OF TWO PART ADJUSTABLE HOLD FASTS WITH BOLT HEADS SLOTTED FOR SCREW DRIVER, ORDINARY W.I. STAYS MAY BE USED IF SO ORDERED.

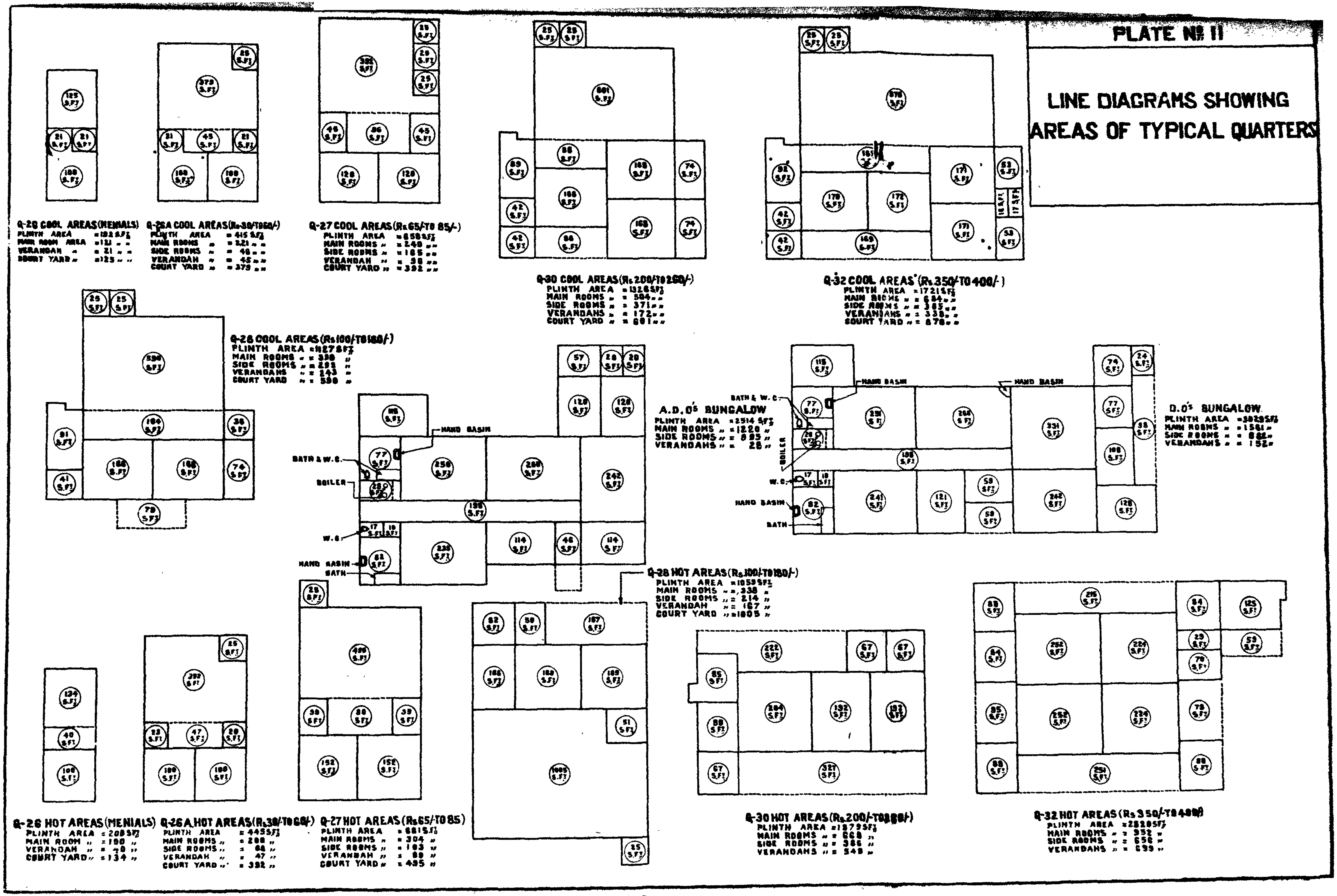
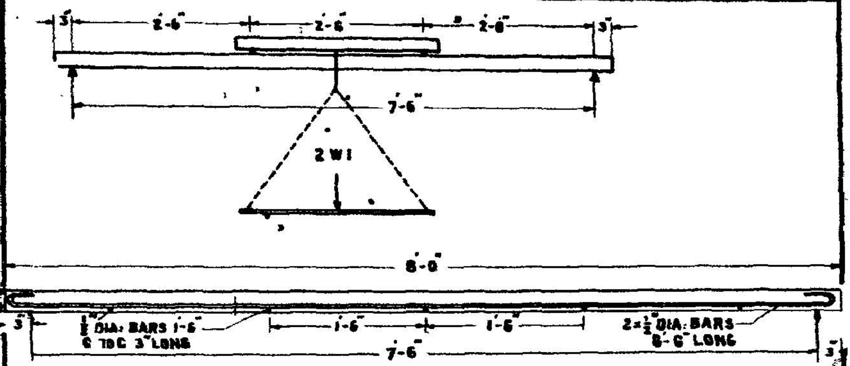
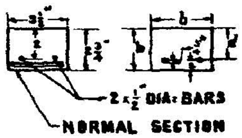


PLATE No. II
LINE DIAGRAMS SHOWING
AREAS OF TYPICAL QUARTERS
Q-26 COOL AREAS (MENIALS)
PLINTH AREA = 192 S.FT.
MAIN ROOM AREA = 121 " "
VERANDAH " = 21 " "
COURT YARD " = 125 " "
Q-26A COOL AREAS (Rs 30/- TO 60/-)
PLINTH AREA = 415 S.FT.
MAIN ROOMS " = 221 " "
SIDE ROOMS " = 46 " "
VERANDAH " = 45 " "
COURT YARD " = 379 " "
Q-27 COOL AREAS (Rs 65/- TO 85/-)
PLINTH AREA = 658 S.FT.
MAIN ROOMS " = 240 " "
SIDE ROOMS " = 165 " "
VERANDAH " = 98 " "
COURT YARD " = 392 " "
Q-30 COOL AREAS (Rs 200/- TO 260/-)
PLINTH AREA = 1326 S.FT.
MAIN ROOMS " = 504 " "
SIDE ROOMS " = 371 " "
VERANDAHS " = 172 " "
COURT YARD " = 601 " "
Q-32 COOL AREAS (Rs 350/- TO 400/-)
PLINTH AREA = 1721 S.FT.
MAIN ROOMS " = 684 " "
SIDE ROOMS " = 385 " "
VERANDAHS " = 338 " "
COURT YARD " = 878 " "
Q-28 COOL AREAS (Rs 100/- TO 180/-)
PLINTH AREA = 1127 S.FT.
MAIN ROOMS " = 338 "
SIDE ROOMS " = 292 "
VERANDAHS " = 243 "
COURT YARD " = 598 "
A.D.O's BUNGALOW
PLINTH AREA = 2514 S.FT.
MAIN ROOMS " = 1220 "
SIDE ROOMS " = 895 "
VERANDAHS " = 28 "
D.O's BUNGALOW
PLINTH AREA = 3029 S.FT.
MAIN ROOMS " = 1561 "
SIDE ROOMS " = 882 "
VERANDAHS " = 152 "
HAND BASIN
BATH & W.C.
BOILER
W.C.
BATH
Q-28 HOT AREAS (Rs 100/- TO 180/-)
PLINTH AREA = 1055 S.FT.
MAIN ROOMS " = 338 "
SIDE ROOMS " = 214 "
VERANDAH " = 167 "
COURT YARD " = 1005 "
Q-26 HOT AREAS (MENIALS)
PLINTH AREA = 208 S.FT.
MAIN ROOM " = 100 "
VERANDAH " = 40 "
COURT YARD " = 134 "
Q-26A HOT AREAS (Rs 30/- TO 60/-)
PLINTH AREA = 445 S.FT.
MAIN ROOMS " = 200 "
SIDE ROOMS " = 66 "
VERANDAH " = 47 "
COURT YARD " = 392 "
Q-27 HOT AREAS (Rs 65/- TO 85)
PLINTH AREA = 681 S.FT.
MAIN ROOMS " = 304 "
SIDE ROOMS " = 103 "
VERANDAH " = 88 "
COURT YARD " = 495 "
Q-30 HOT AREAS (Rs 200/- TO 260/-)
PLINTH AREA = 1879 S.FT.
MAIN ROOMS " = 668 "
SIDE ROOMS " = 386 "
VERANDAHS " = 548 "
Q-32 HOT AREAS (Rs 350/- TO 400/-)
PLINTH AREA = 2520 S.FT.
MAIN ROOMS " = 952 "
SIDE ROOMS " = 656 "
VERANDAHS " = 699 "

PLATE №. 12

BEAM TESTING SHEET





DATE OF CASTING .... 1.11.37 AT 17.00 HOURS.
DATE OF TESTING............ 8.11.37 AT 17.00 HOURS & 29-11-37 AT 17.00 HOURS.
AGE IN DAYS........................ 7 DAYS ___ & ___ 28 DAYS.
CONCRETE MIX. IN PROPORTION......REAL 1:7 1/33 ; NOMINAL 1:2.56:5.70; FIELD 1:2.88:6.49.
SLUMP TEST........ 3 1/4 FOR 3.50 GALLONS OF WATER USED PER 1/2 BAG OF CEMENT IN THE MIX.
LOCATION OF MIX:...... E-3 HOSPITAL AREA MENIAL QUARTERS TYPE Q-26 OF 2 UNITS (BOTTOM R.C. BANDS)
SIZE OF AGGREGATE......... 3/4"

	7 DAYS №. 1	7 DAYS №. 2	7 DAYS №. 3	28 DAYS №. 1	28 DAYS №. 2	28 DAYS №. 3
WEIGHT OF TANK AND OTHER ADJUSTMENTS IN LBS.	274	274	274	443	443	443
WEIGHT OF WATER IN TANK, AT FAILURE, IN LBS,	680	320	580	800	900	870
TOTAL APPLIED LOAD AT FAILURE = 2 W IN LBS.	954	594	854	1243	1343	1213
b = WIDTH OF BEAM AT SECTION OF FAILURE IN INCHES.	3·5	3·5	3·5	3·5	3·5	3·5
e = DISTANCE BETWEEN BOTTOM OF BEAM & BOTTOM OF REINFORCEMENT IN INCHES.	0·5	0·5	0·5	0·5	0·5	0·5
d = EFF. DEPTH OF BEAM AT SECTION OF FAILURE IN INCHES	2·0	2·0	2·0	2·0	2·0	2·0
VALUE OF α	5·77	5·77	5·77	5·77	5·77	5·77
BREAKING STRENGTH C_b = $\alpha W + 175$ IN LBS/SQ"	2927	1889	2639	3761	4050	3963

7 DAYS:
AVERAGE BEAM STRENGTH = 2485 LBS/SQ"
— " — CUBE — " — = 1988 " /SQ"
— " — CYLINDER — " — = 1590 " /SQ"

28 DAYS:
(1) AVERAGE BEAM STRENGTH = 3925 LBS/□"
(2) " CUBE — " — = 3140 " /□"
(3) " CYLINDER — " — = 2512 " /□"

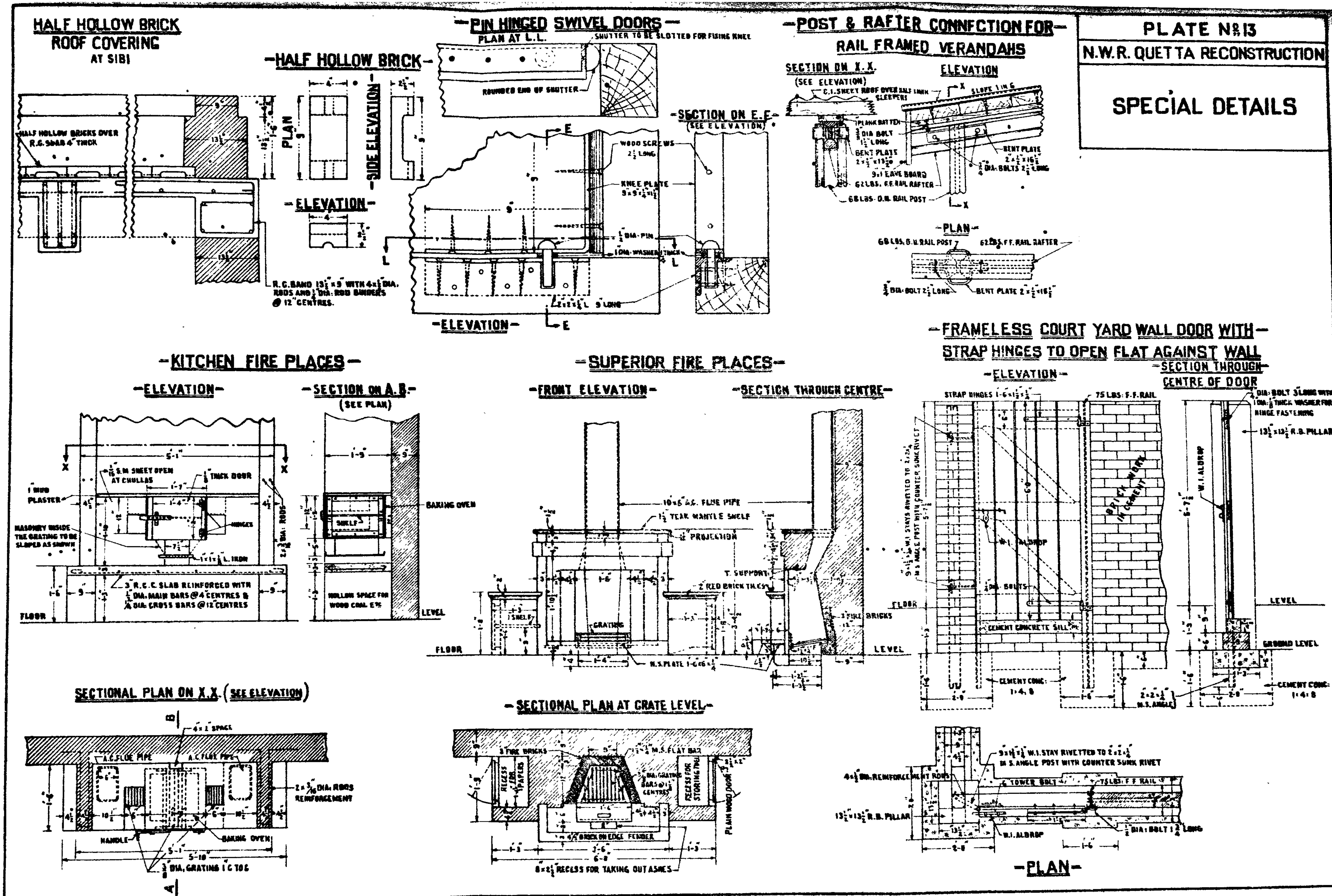


PLATE No. 13
N.W.R. QUETTA RECONSTRUCTION
SPECIAL DETAILS
HALF HOLLOW BRICK ROOF COVERING AT SIBI
HALF HOLLOW BRICKS OVER R.C. SLAB 4" THICK
R.C. BAND 13½" x 9" WITH 4 x ½" DIA. RODS AND ¼" DIA. ROD BINDERS @ 12" CENTRES.
-HALF HOLLOW BRICK-
PLAN
SIDE ELEVATION
-ELEVATION-
-PIN HINGED SWIVEL DOORS-
PLAN AT L.L.
SHUTTER TO BE SLOTTED FOR FIXING KNEE
ROUNDED END OF SHUTTER
-SECTION ON E.F.-
(SEE ELEVATION)
WOOD SCREWS 2½" LONG
KNEE PLATE
-ELEVATION-
-POST & RAFTER CONNECTION FOR-
RAIL FRAMED VERANDAHS
SECTION ON X.X.
(SEE ELEVATION)
ELEVATION
C.I. SHEET ROOF OVER
PLANK BATTEN
BENT PLATE
9 x 1 EAVE BOARD
62 LBS. F.F. RAIL RAFTER
68 LBS. D.H. RAIL POST
-PLAN-
68 LBS. D.H. RAIL POST
62 LBS. F.F. RAIL RAFTER
-KITCHEN FIRE PLACES-
-ELEVATION-
-SECTION ON A.B.-
(SEE PLAN)
1" MUD PLASTER
AT CHULLAS
HINGES
MASONRY INSIDE THE GRATING TO BE SLOPED AS SHOWN
3" R.C.C. SLAB REINFORCED WITH
BAKING OVEN
SHELF
HOLLOW SPACE FOR WOOD COAL ETC
FLOOR
LEVEL
SECTIONAL PLAN ON X.X. (SEE ELEVATION)
A.C. FLUE PIPE
HANDLE
BAKING OVEN
-SUPERIOR FIRE PLACES-
-FRONT ELEVATION-
-SECTION THROUGH CENTRE-
10 x 6" A.C. FLUE PIPE
1½" TEAK MANTLE SHELF
T. SUPPORT
2" RED BRICK TILES
FIRE BRICKS
GRATING
SHELF
FLOOR
LEVEL
-SECTIONAL PLAN AT GRATE LEVEL-
3 FIRE BRICKS
RECESS FOR PAPERS
RECESS FOR STORING FUEL
PLAIN WOOD DOOR
8 x 2½" RECESS FOR TAKING OUT ASHES
-FRAMELESS COURT YARD WALL DOOR WITH-
STRAP HINGES TO OPEN FLAT AGAINST WALL
-ELEVATION-
-SECTION THROUGH CENTRE OF DOOR-
75 LBS. F.F. RAIL
BRICK WORK IN CEMENT
W.I. ALDROP
CEMENT CONCRETE SILL
FLOOR
LEVEL
GROUND LEVEL
CEMENT CONC: 1:4:8
13½" x 13½" R.B. PILLAR
TOWER BOLT
75 LBS. F.F. RAIL
W.I. ALDROP
-PLAN-

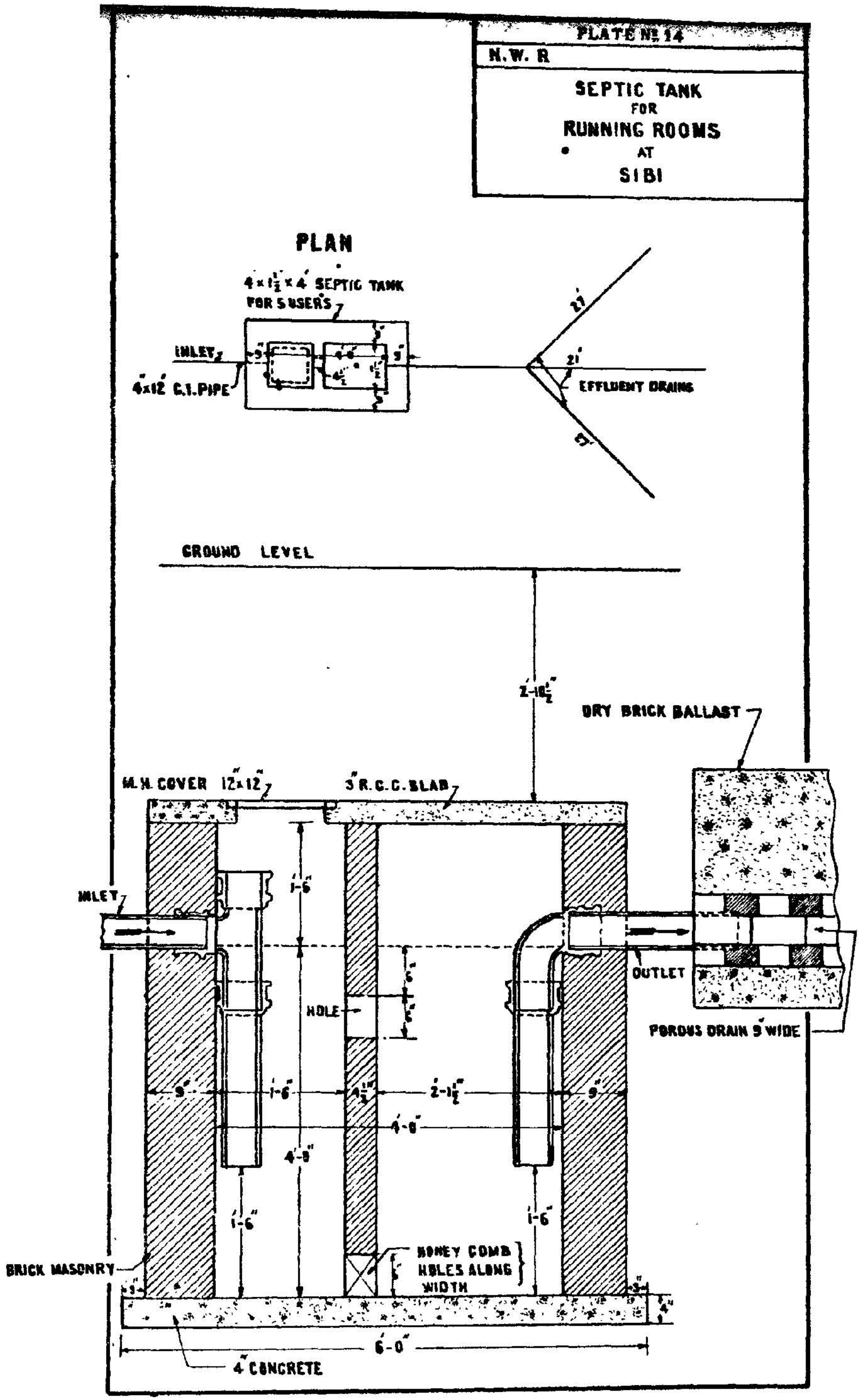


PLATE No 14
N.W. R
SEPTIC TANK
FOR
RUNNING ROOMS
AT
SIBI
PLAN
4 × 1½ × 4 SEPTIC TANK
FOR 5 USERS
INLET
4 × 12 C.I. PIPE
EFFLUENT DRAINS
GROUND LEVEL
2-10½
DRY BRICK BALLAST
M.H. COVER 12 × 12
3 R.C.C. SLAB
INLET
OUTLET
HOLE
POROUS DRAIN 9 WIDE
BRICK MASONRY
HONEY COMB
HOLES ALONG
WIDTH
6-0
4 CONCRETE

BOOKS AND TECHNICAL PAPERS PUBLISHED BY THE RAILWAY BOARD

Books.

(1) Administration Report on the Railways in India. Published yearly. Price, Volume I, Report, Rs. 6-10-0 or 10*s*. 6*d*. Volume II, Appendices, Rs. 6-6-0 or 10s. (1938-39).

(2) Classified List and Distribution Return of Officers of all Indian Railways. Published yearly. Price Re. 1-12-0 or 3*s*.

(3) History of Indian Railways constructed and in progress, corrected up to 31st March 1939 (published sexennially). Price Rs. 4-10-0 or 7*s*. 3*d*.

(4) History of Services of the Officers of the Indian State Railways. Published every 2 years. Price Rs. 20-0-0 or 31*s*.

Technical Papers.

(6) Over 306 papers have been published by the Railway Board's Office. The papers comprise—

(a) Original descriptions of railway works and studies of railway problems in India and elsewhere.

(b) Reprints of articles from foreign Engineering Magazines.

(c) Reprints of abstracts of reports received by the Government of India on subjects connected with railways.

A complete list of the papers can be obtained gratis from the Chief Controller, Standardization, Central Standards Office for Railways, New Delhi.

The prices of the papers vary from annas three to rupees fifteen.

The books and papers can be bought from the Manager of Publications, Delhi, and his Agents.

261—85 6-1-41—EIR.